9　添付資料

本文で説明した重要文献ならびに調査資料を，まとめて巻末に添付資料として収録した。

資　料　3

地熱開発状況関係資料

Fig.3.1　Luzon Power Project

Fig.3.2　Regional Distribution of Geothermal Areas and Pliocene-Quaternary Volcanics in the Philippines

Fig.3.3　Philippine Geothermal Operation Map

資料3.4　電力開発計画（pp.13）

Fig.3.5　Geothermal Prospects , Synoptical Data Map

Fig.3.6　Statistics of Wind Velosity Due To Tropical Cyclones

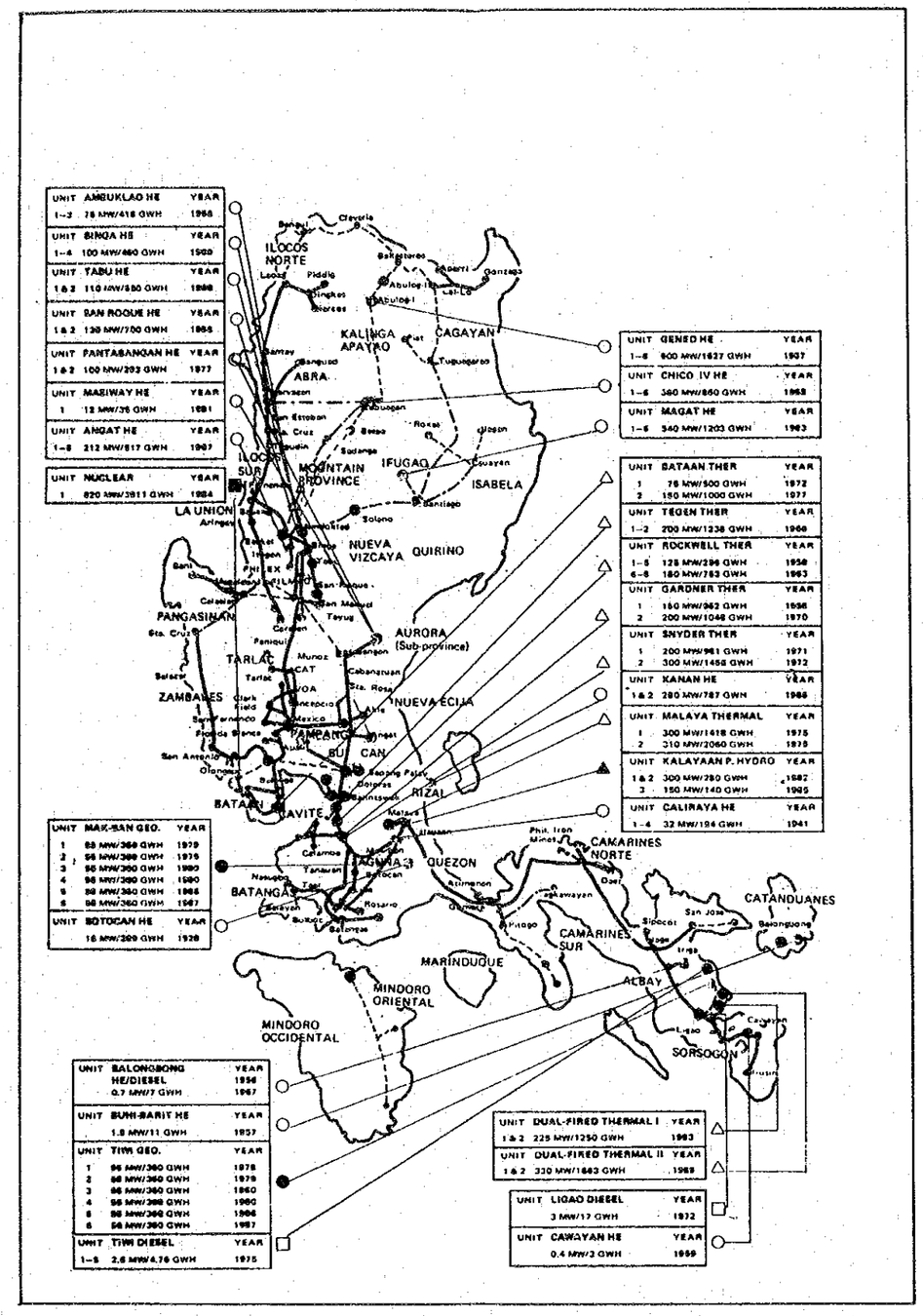


Fig 3. 1 LUZON POWER PROJECT (after NPC's data)

PRELIMINARY SURVEY FOR THE GEOTHERMAL DEVELOPMENT PLAN IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

L E G E N D

GENERATING PLANTS

- ○ · HYDROELECTRIC PLANT
- △ · THERMAL PLANT
- □ · DIESEL PLANT
- ● · GEOTHERMAL PLANT
- ▲ · PUMP STORAGE PLANT
- ■ · NUCLEAR PLANT

SUBSTATION

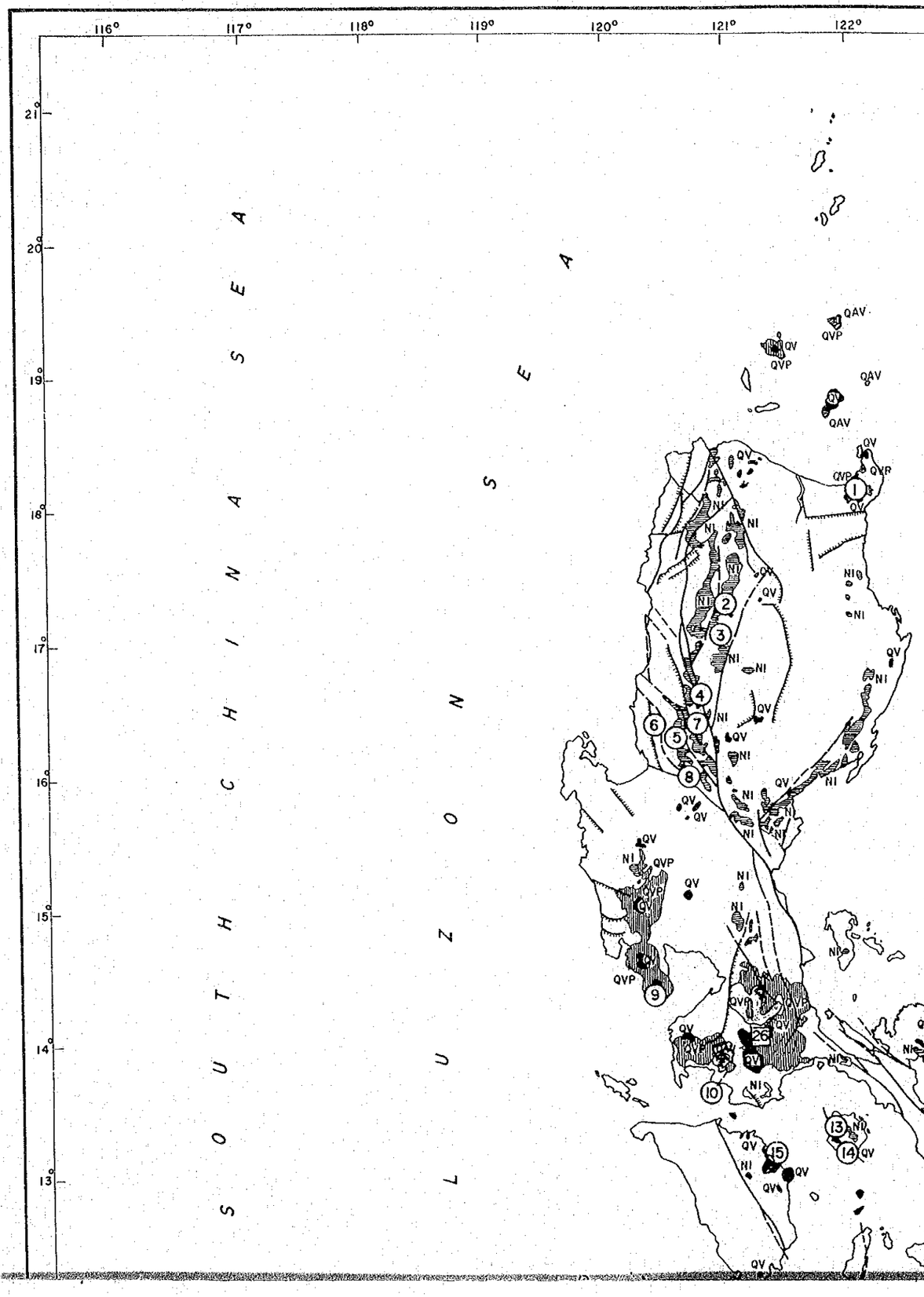
- ⊕ · MAIN SUBSTATION
- ⊞ · LOAD END SUBSTATION

TRANSMISSION LINE

- EXISTING ——————
- UNDER CONST. —— — ——
- PROPOSED - - - - - - -

PRELIMINARY SURVEY F
GEOTHERMAL DEVELOPME
IN THE REPUBLIC OF T
PHILIPPINES

JAPAN INTERNATIONAL COOPERA
AGENCY



EXPLANATION

○ GEOTHERMAL AREA COVERED BY PRELIMINARY

1. CAGUA	14. BUENAVISTA
2. BATONG-BUHAY	15. MONTELAGO
3. MAINIT-BONTOC	16. BILIRAN
4. BUGUIAS	17. ANAHAWAN
5. ACUPAN-ITOGON	18. MAAYON
6. ASIN	19. SIRAAN
7. DAKLAN-BOKOD	20. BULOC-BULOC
8. BALUNGAO	21. MONTANEZA
9. BALONG ANITO	22. SANTANDER
10. MABINI	23. STA. LUCIA
11. IRIGA-ISAROG	24. MAINIT-PLACER
12. SANBIÑONMAPASO	25. BALATUKAN
13. MAINIT-BOAC	

□ GEOTHERMAL FIELD UNDER EXPLORATION/DEVE

26. MAKILING BANAHAW	30. MANDALAGAN
27. TIWI	31. MAMBUKAL
28. MANITO	32. PALIMPINON-DAUIN
29. TONGONAN	33. MANAT

LITHOLOGY	GEOLOGIC TIME	DESCRI
QAV	: QUATERNARY	– Active volcano with eruption
QVP	: PLIOCENE-QUATERNARY	– Volcanic plain or volcanic pie
QV	: PLIOCENE-QUATERNARY	– Non-active cones; also dacitic
NI	: NEOGENE	– Largely Intra-Miocene quartz and stocks

STRUCTURE

Geologic contact

PRELIMINARY SURVEY FOR THE GEOTHERMAL DEVELOPMENT PLAN IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

EXPLANATION

○ GEOTHERMAL AREA COVERED BY PRELIMINARY INVENTORY

1. CAGUA	14. BUENAVISTA
2. BATONG-BUHAY	15. MONTELAGO
3. MAINIT-BONTOC	16. BILIRAN
4. BUGUIAS	17. ANAHAWAN
5. ACUPAN-ITOGON	18. MAAYON
6. ASIN	19. SIRAAN
7. DAKLAN-BOKOD	20. BULOC-BULOC
8. BALUNGAO	21. MONTANEZA
9. BALONG ANITO	22. SANTANDER
10. MABINI	23. STA. LUCIA
11. IRIGA-ISAROG	24. MAINIT-PLACER
12. SANBIÑONMAPASO	25. BALATUKAN
13. MAINIT-BOAC	

□ GEOTHERMAL FIELD UNDER EXPLORATION/DEVELOPMENT BY PNOC-EDC Or PGI

26. MAKILING BANAHAW	30. MANDALAGAN
27. TIWI	31. MAMBUKAL
28. MANITO	32. PALIMPINON-DAUIN
29. TONGONAN	33. MANAT

LITHOLOGY	GEOLOGIC TIME	DESCRIPTION
QAV	: QUATERNARY	— Active volcano with eruption and/or activity since 1616
QVP	: PLIOCENE-QUATERNARY	— Volcanic plain or volcanic piedmont deposit
QV	: PLIOCENE-QUATERNARY	— Non-active cones; also dacitic or andesitic plug
NI	: NEOGENE	— Largely intra-Miocene quartz diorite; mostly batholiths and stocks

STRUCTURE

Geologic contact

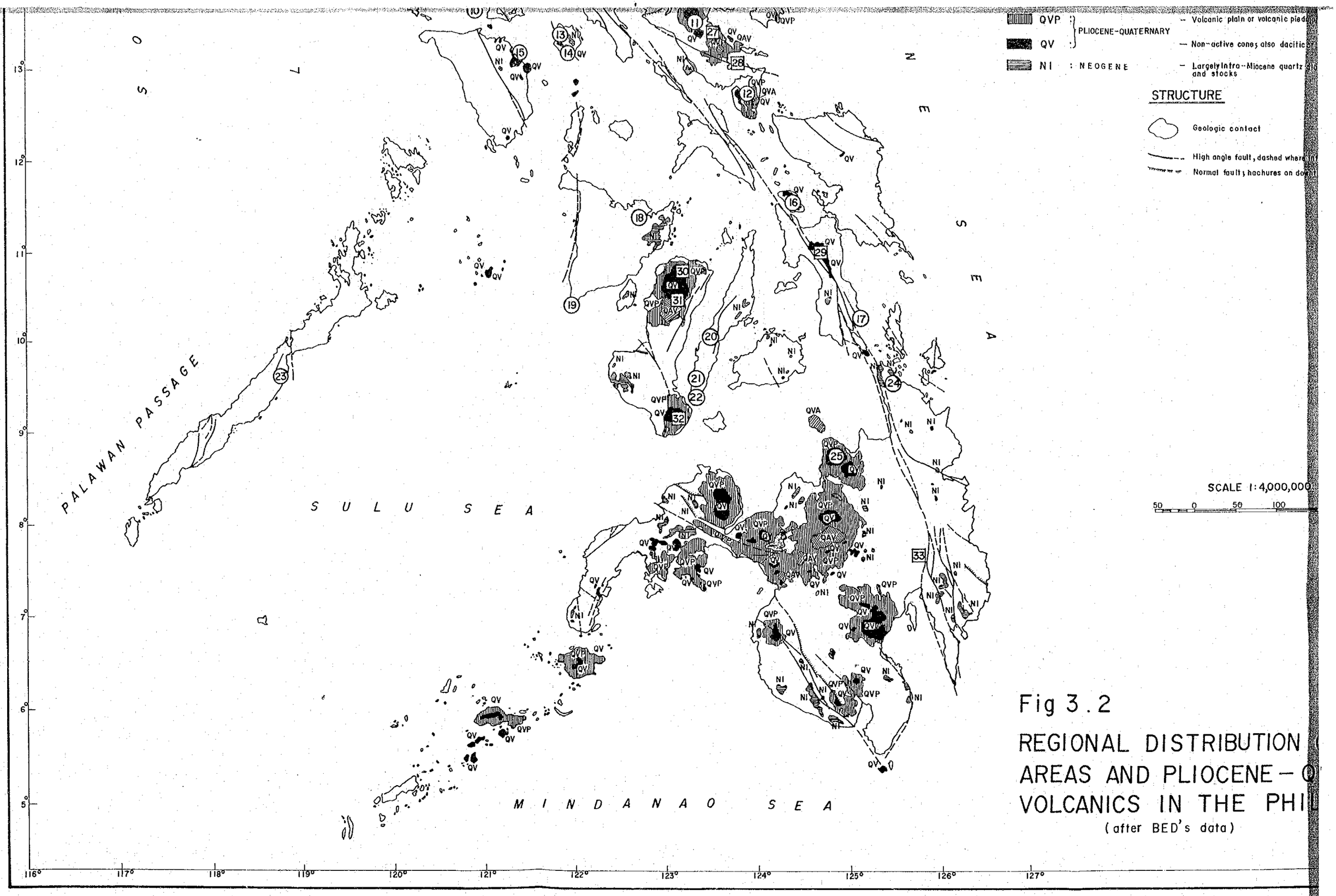


Fig 3.2

REGIONAL DISTRIBUTION
AREAS AND PLIOCENE – Q
VOLCANICS IN THE PHI

(after BED's data)

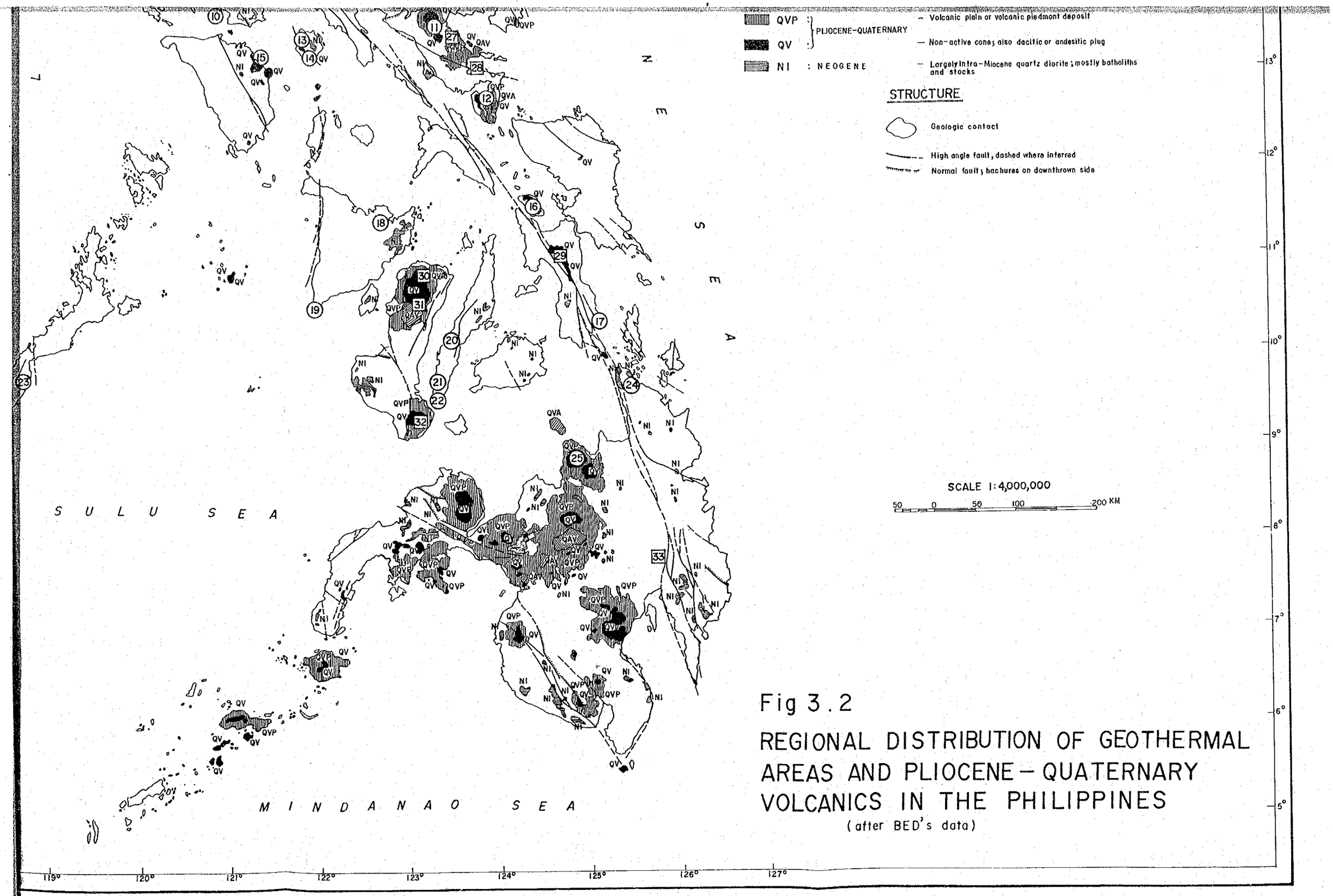
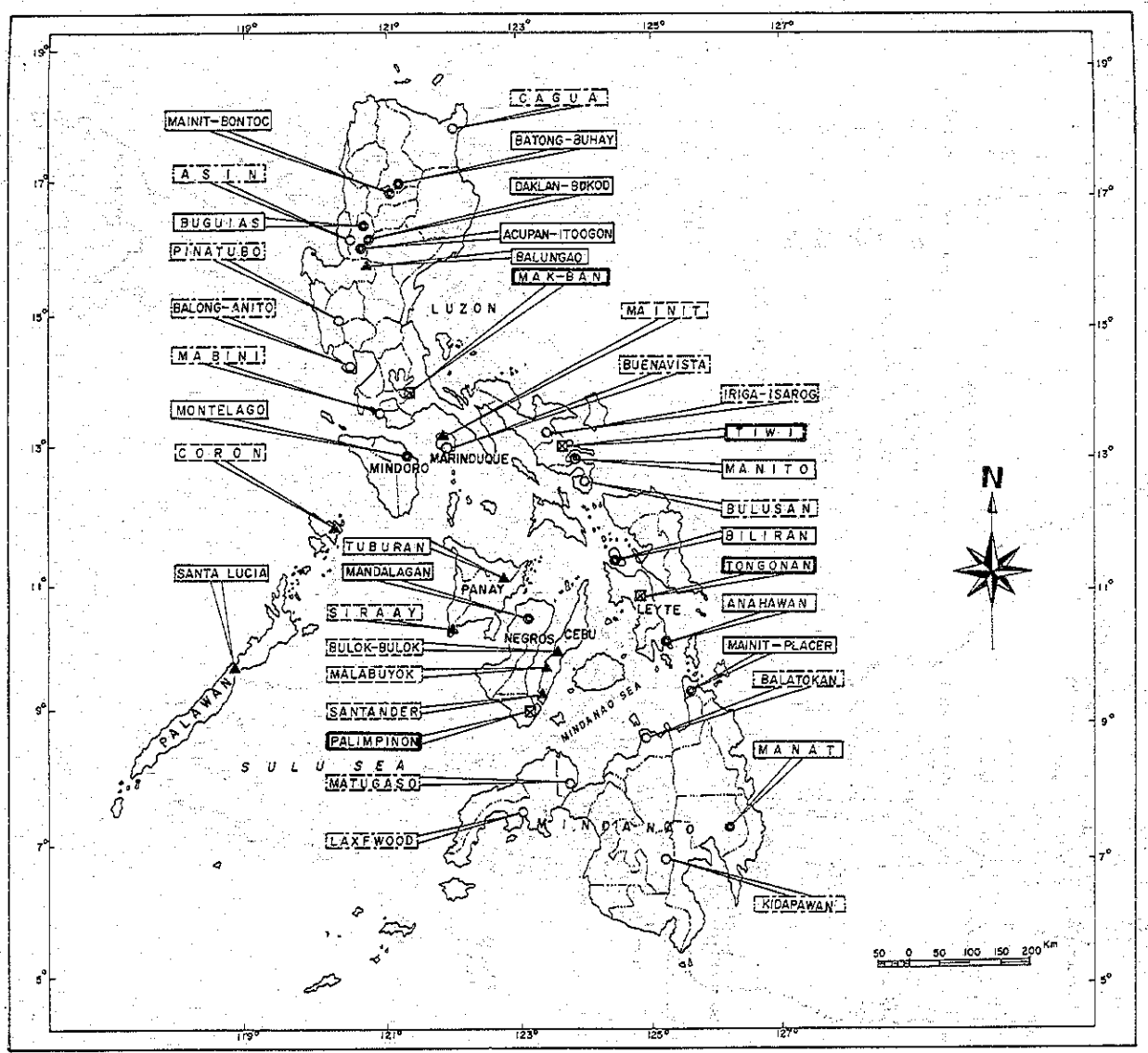


Fig 3.2

REGIONAL DISTRIBUTION OF GEOTHERMAL AREAS AND PLIOCENE-QUATERNARY VOLCANICS IN THE PHILIPPINES

(after BED's data)



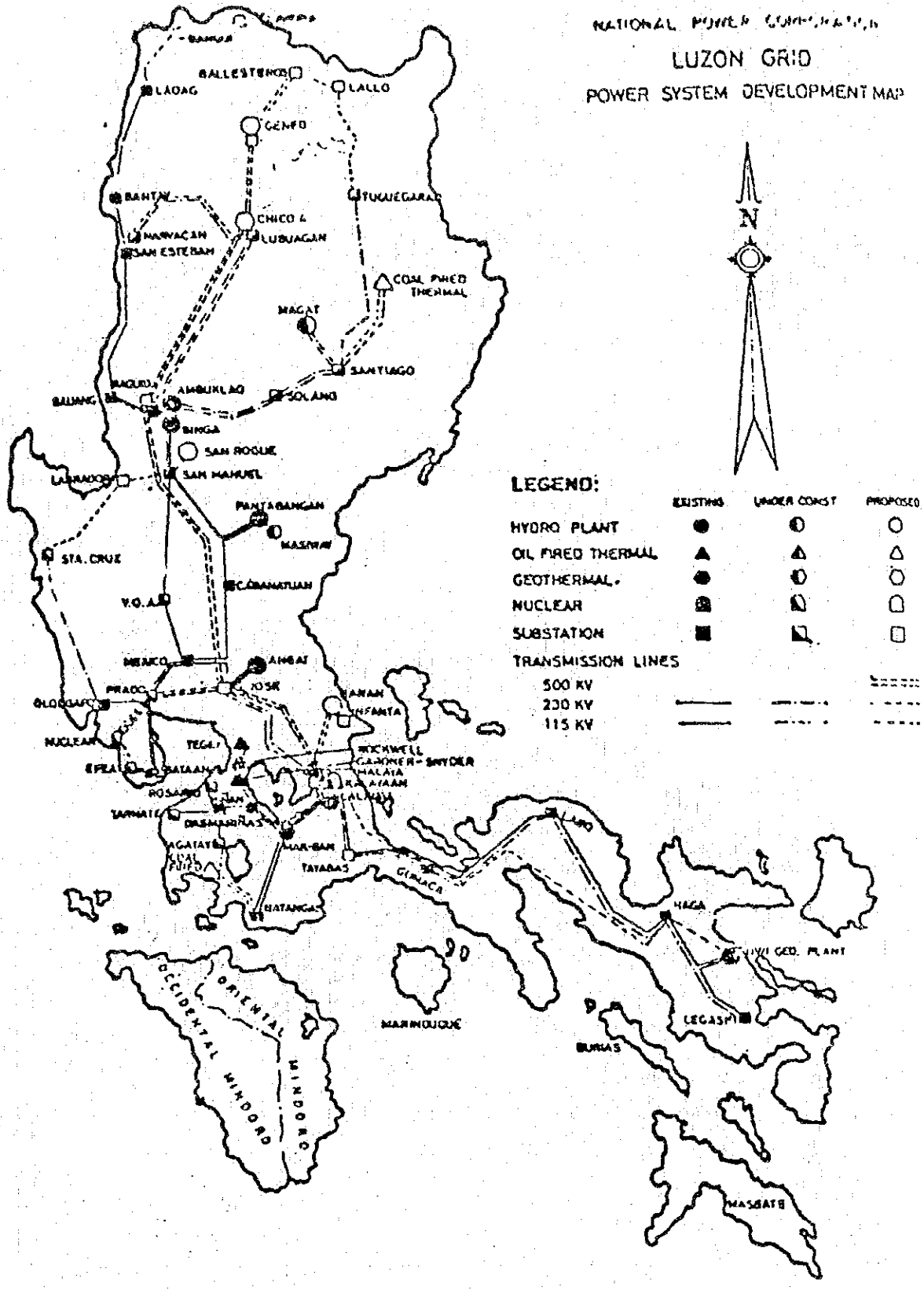
PRELIMINARY SURVEY FOR THE GEOTHERMAL DEVELOPMENT PLAN IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

LEGEND

- ⊛ PROMISING THERMAL AREAS (On going preliminary assessment)
- ○ SECOND PRIORITY AREAS. (For future preliminary assessment)
- ▲ AREAS WITH NO ECONOMIC GEOTHERMAL POTENTIALS
- ⊠ AREAS UNDER EXPLOITATION / DEVELOPMENT BY PNOC-EDC / PGI-NPC

Fig 3.3 PHILIPPINE GEOTHERMAL OPERATION MAP (after BED's data)


NATIONAL POWER CORPORATION
LUZON GRID
POWER SYSTEM DEVELOPMENT MAP
N
LEGEND:
EXISTING
UNDER CONST
PROPOSED
HYDRO PLANT
OIL FIRED THERMAL
GEOTHERMAL
NUCLEAR
SUBSTATION
TRANSMISSION LINES
500 KV
230 KV
115 KV
BANGUI
BALLESTEROS
LAOAG
LALLO
GONFO
BANTAY
TUGUEGARAO
CHICO 4
LUBUAGAN
NAGUILIAN
SAN ESTEBAN
COAL FIRED THERMAL
MAGAT
SANTIAGO
BAGUIO
AMBUKLAO
BALING
SOLANO
BINGA
SAN ROQUE
SAN MANUEL
LABRADOR
PANTABANGAN
MASINAG
STA. CRUZ
CABANATUAN
V.O.A.
MEXICO
AMBAT
PRADO
JOSR
BANAN
OLONGAPO
NUCLEAR
TEGA I
EPZA
BATAAN
MICHWELL
GAMONER-SNYDER
MALAYA
ROSARIO
TAMAYO
AGATAYA
TAYABAS
GUMACA
BATANGAS
LAO
HAGA
LEGASPI
BURIAS
MARINDUQUE
MASBATE
ORIENTAL MINDORO
OCCIDENTAL MINDORO

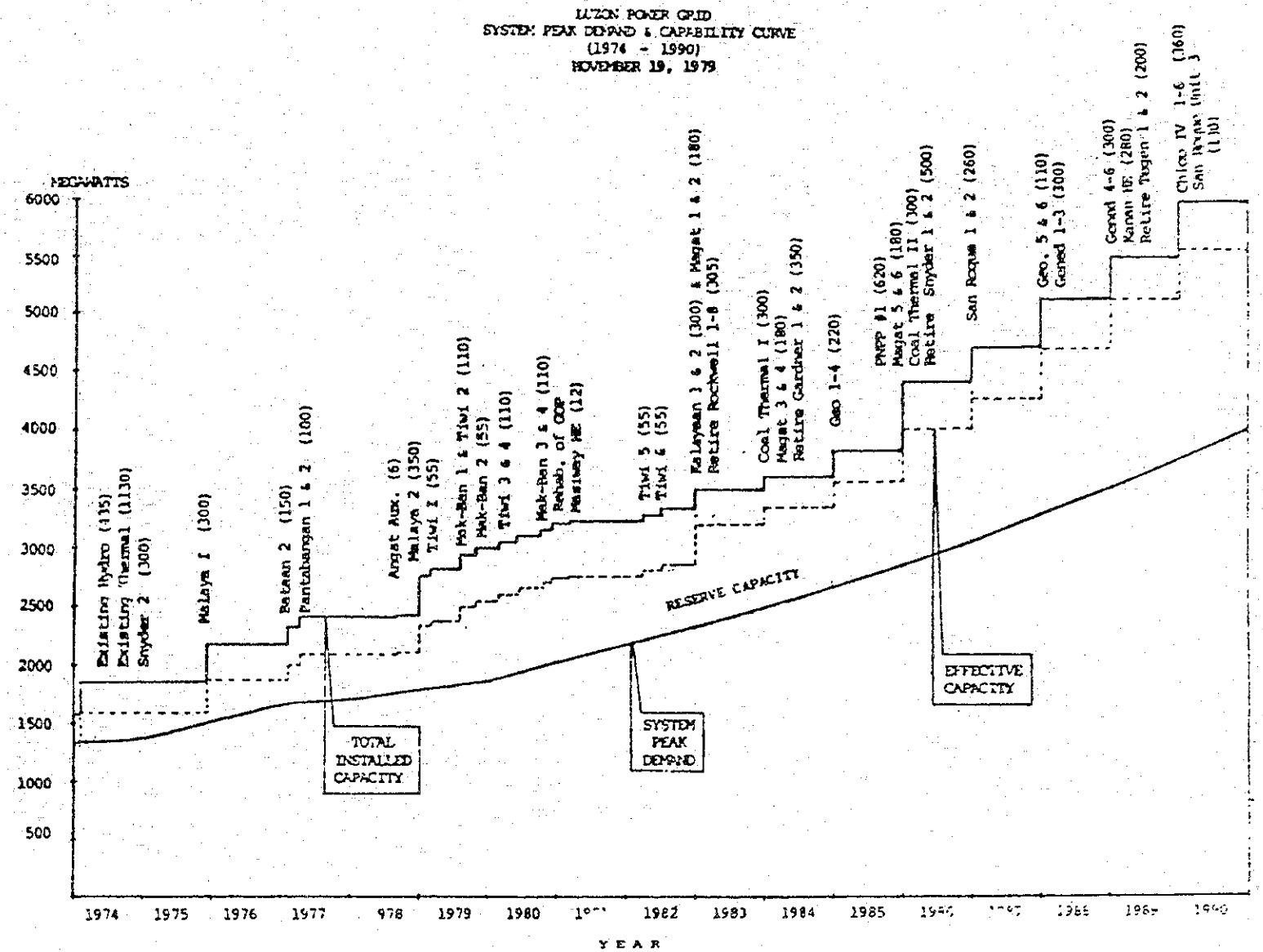
資料３．４　　電力開発計画

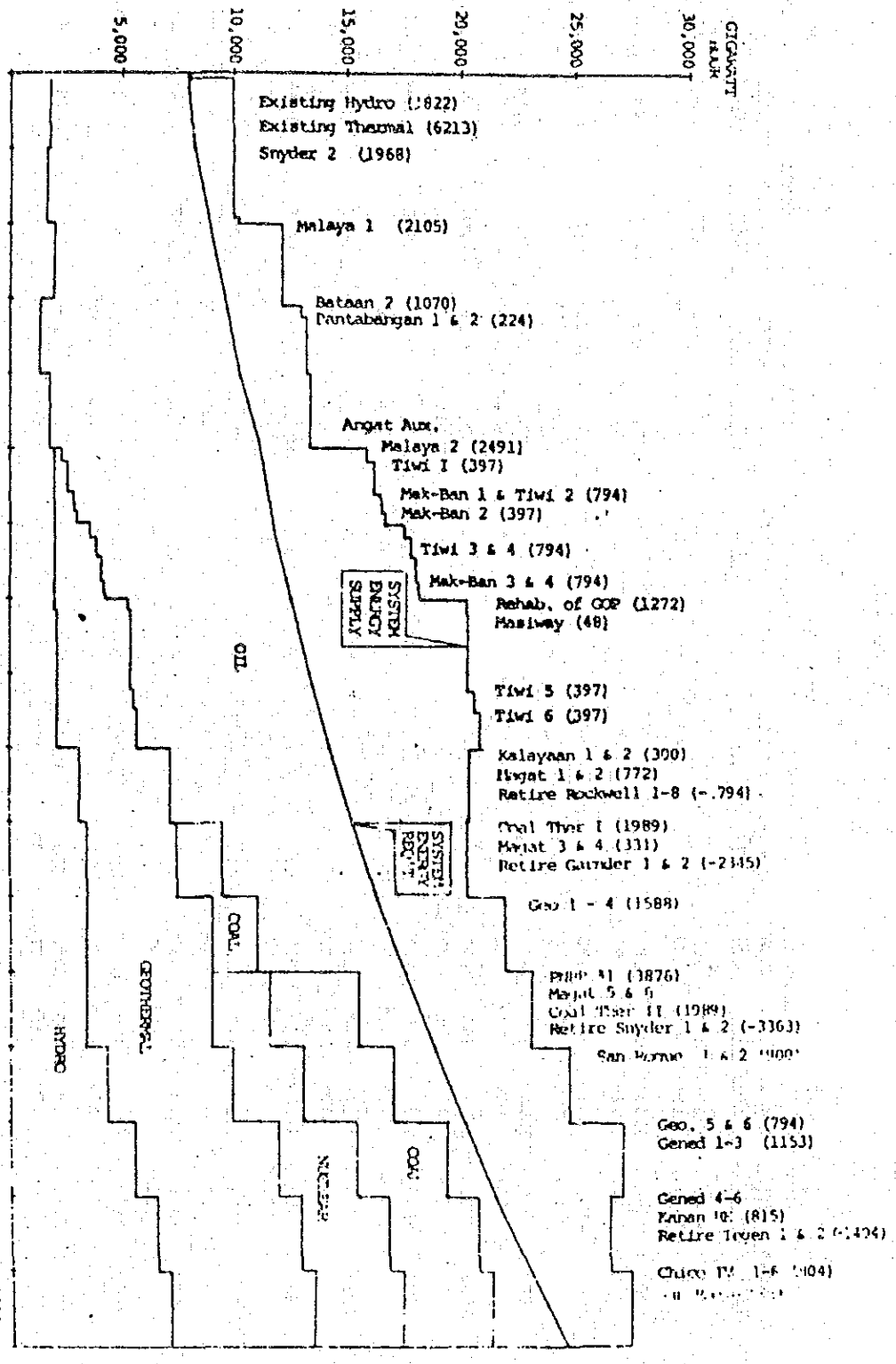
LUZON GRID LOAD FORECAST

(GENERATION LEVEL)

YEAR	DEMAND	ENERGY (GWH)
ACTUAL		
1968	903	5387
1969	1020	6087
70	1111	6386
71	1205	7048
72	1331	7555
73	1335	8212
1969 - 1973	8.1%	8.8%
1974	1379	8240
75	1513	9014
76	1659	9676
77	1709	10357
78	1780	11223
1974 - 1978	5.9%	6.4%
1969 - 1978	7.0%	7.6%
FORECAST		
1979	1905	11765
80	2038	12497
81	2180	13368
82	2333	14306
83	2496	15305
1979 - 1983	7.0%	6.4%
1984	2671	16379
85	2858	17525
86	3058	18752
87	3272	20064
88	3502	21474
1984 - 1988	7.0%	7.0%
1989	3747	22977
90	4009	24583
1989 - 1990	7.0%	7.0%
1979 - 1990	7.0%	6.8%

SPD - CORPLAN
11-19-79/tgi


LUZON POWER GRID
SYSTEM PEAK DEMAND & CAPABILITY CURVE
(1974 - 1990)
NOVEMBER 19, 1979
MEGAWATTS
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
YEAR
Existing Hydro (115)
Existing Thermal (1130)
Snyder 2 (300)
Malaya 1 (300)
Bataan 2 (150)
Pantabangan 1 & 2 (100)
Angat Aux. (6)
Malaya 2 (350)
Tiwi 1 (55)
Mak-Ban 1 & Tiwi 2 (110)
Mak-Ban 2 (55)
Tiwi 3 & 4 (110)
Mak-Ban 3 & 4 (110)
Rehab. of GOP
Masiway HE (12)
Tiwi 5 (55)
Tiwi 6 (55)
Kalayaan 1 & 2 (300) & Magat 1 & 2 (180)
Retire Rockwell 1-8 (305)
Coal Thermal I (300)
Magat 3 & 4 (180)
Retire Gardner 1 & 2 (350)
Geo 1-4 (220)
PNPP #1 (620)
Magat 5 & 6 (180)
Coal Thermal II (300)
Retire Snyder 1 & 2 (500)
San Roque 1 & 2 (260)
Geo. 5 & 6 (110)
Gensd 1-3 (300)
Gensd 4-6 (300)
Kanan HE (280)
Retire Tagen 1 & 2 (200)
Chico IV 1-6 (360)
San Roque Unit 3 (1,10)
RESERVE CAPACITY
TOTAL INSTALLED CAPACITY
SYSTEM PEAK DEMAND
EFFECTIVE CAPACITY

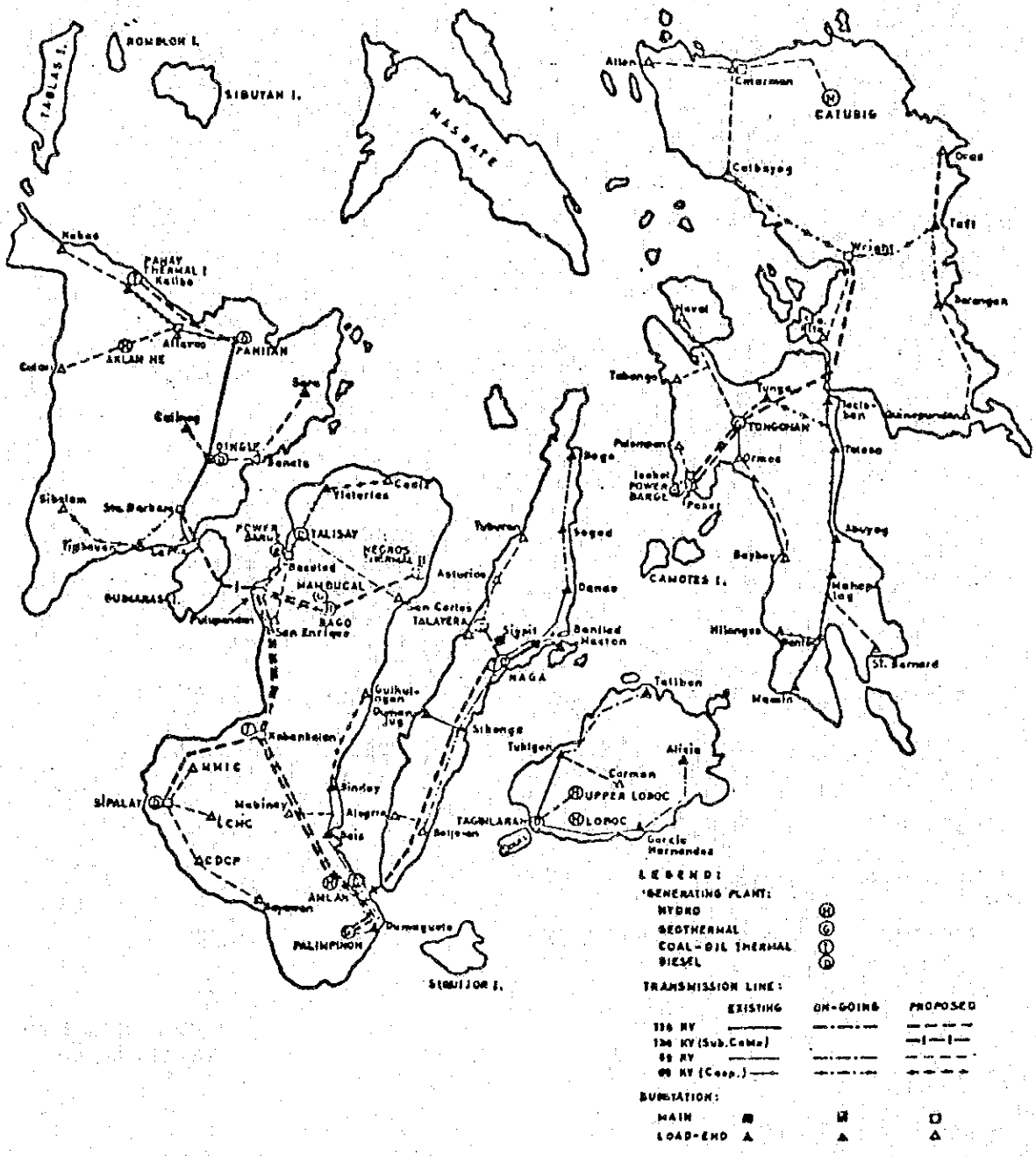

5,000
10,000
15,000
20,000
25,000
30,000
GIGAWATT HOUR
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
YEAR
Existing Hydro (1822)
Existing Thermal (6213)
Snyder 2 (1968)
Malaya 1 (2105)
Bataan 2 (1070)
Pantabangan 1 & 2 (224)
Angat Aux.
Malaya 2 (2491)
Tiwi I (397)
Mak-Ban 1 & Tiwi 2 (794)
Mak-Ban 2 (397)
Tiwi 3 & 4 (794)
Mak-Ban 3 & 4 (794)
Rehab. of GOP (1272)
Masiway (48)
Tiwi 5 (397)
Tiwi 6 (397)
Kalayaan 1 & 2 (300)
Ingat 1 & 2 (772)
Retire Rockwell 1-8 (-.794)
Coal Thar I (1989)
Magat 3 & 4 (331)
Retire Gardner 1 & 2 (-2345)
Geo 1 - 4 (1588)
Retire Snyder 1 & 2 (-3363)
Geo. 5 & 6 (794)
Gened 1-3 (1153)
Gened 4-6
Retire Tayen 1 & 2 (-1424)
OIL
COAL
GEOTHERMAL
HYDRO
NUCLEAR
COAL
SYSTEM ENERGY SUPPLY

PERCENTAGE INSTALLED CAPACITY
AND GENERATION MIX
LUZON GRID

CALENDAR YEAR	HYDRO CAP. MW	HYDRO ENERGY GWH	GEOTHERMAL CAP. MW	GEOTHERMAL ENERGY GWH	NUCLEAR CAP. MW	NUCLEAR ENERGY GWH	COAL FIRED THERMAL CAP. MW	COAL FIRED THERMAL ENERGY GWH	OIL THERMAL CAP. MW	OIL THERMAL ENERGY GWH	TOTAL INSTALLED CAP.	ENERGY REQ'T.	EQUIVALENT BARREL OF OIL
1979	541	2046	220	793					2230	8926	2991	11765	19.61 M
	18%	17%	7%	7%					75%	76%			
1980	541	2046	440	2283					2230	8168	3211	12497	20.83 M
	17%	17%	14%	18%					69%	65%			
1981	553	2086	440	3176					2230	8106	3223	13368	22.26 M
	17%	15%	14%	24%					69%	61%			
1982	553	2094	550	3673					2230	8539	3333	14306	23.84 M
	16%	15%	17%	26%					67%	59%			
1983	1033	3166	550	3970					1925	8184	3508	15320	25.53 M
	29%	21%	16%	26%					55%	53%			
1984	1213	3497	550	3970			300	1989	1575	6953	3638	16409	27.35 M
	34%	22%	15%	24%			8%	12%	43%	42%			
1985	1213	3497	770	5558			300	1989	1575	6510	3858	17554	29.26 M
	31%	20%	20%	32%			8%	11%	41%	37%			
1986	1393	3497	770	5558	620	2584	600	3978	1075	3219	4458	16836	31.39 M
	31%	19%	17%	29%	14%	14%	14%	21%	24%	17%			
1987	1653	4397	770	5558	620	3101	600	3978	1075	3150	4718	20184	33.64 M
	35%	22%	16%	28%	13%	15%	13%	20%	23%	15%			
1988	1953	5550	880	6352	620	3618	600	3978	1075	2027	5128	21525	35.88 M
	38%	26%	17%	30%	12%	17%	12%	18%	21%	9%			
1989	2533	6365	880	6352	620	3876	600	3978	875	2556	5508	23127	38.55 M
	46%	28%	16%	27%	11%	17%	11%	17%	16%	11%			
1990	3023	7169	880	6352	620	3876	600	3978	875	3349	5998	24724	41.21 M
	50%	29%	15%	26%	10%	16%	10%	16%	15%	13%			

SPD-COR
11-22-79

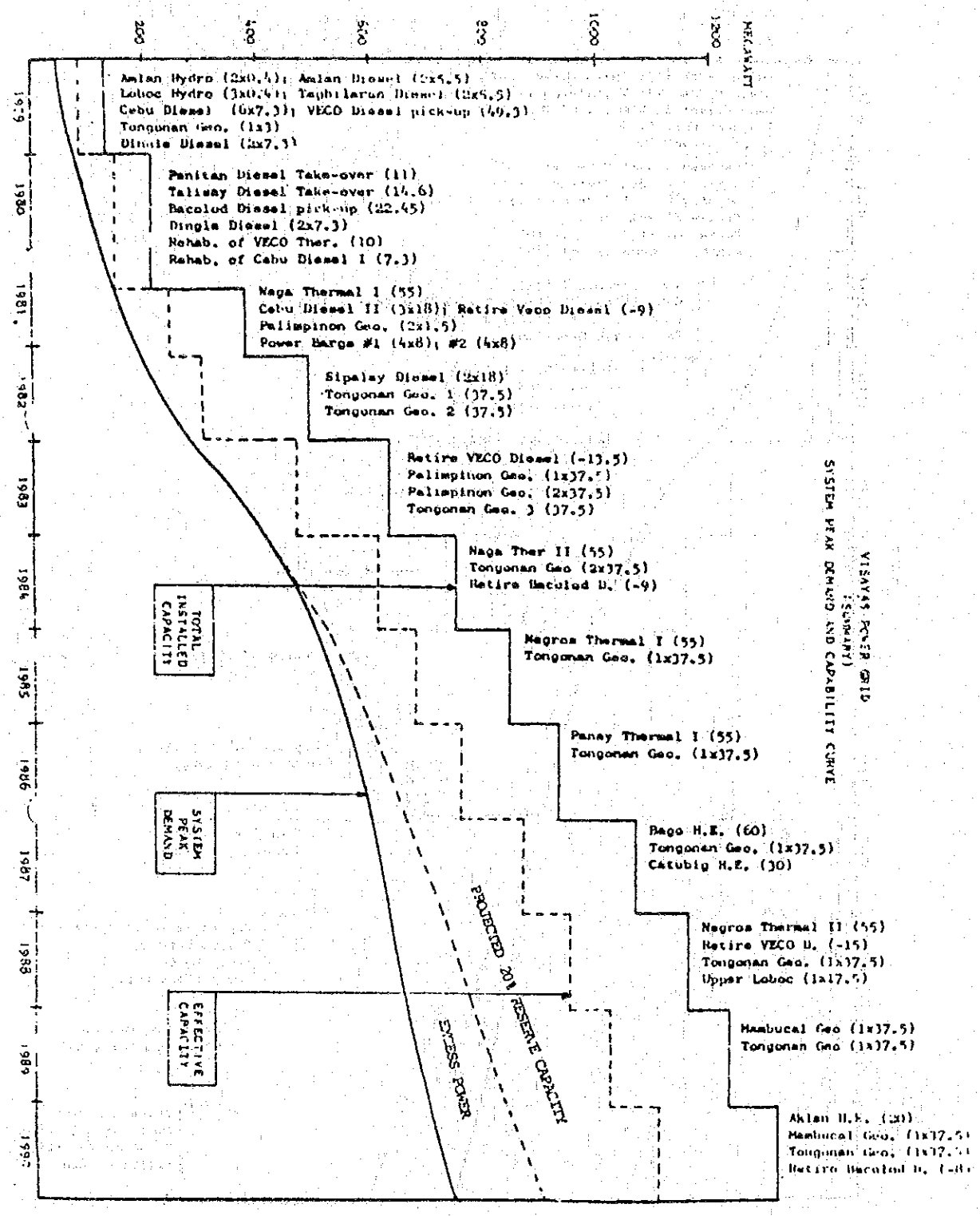
NATIONAL POWER CORPORATION
SYSTEM DEVELOPMENT MAP
VISAYAS POWER GRIDS
OCTOBER 2, 1979

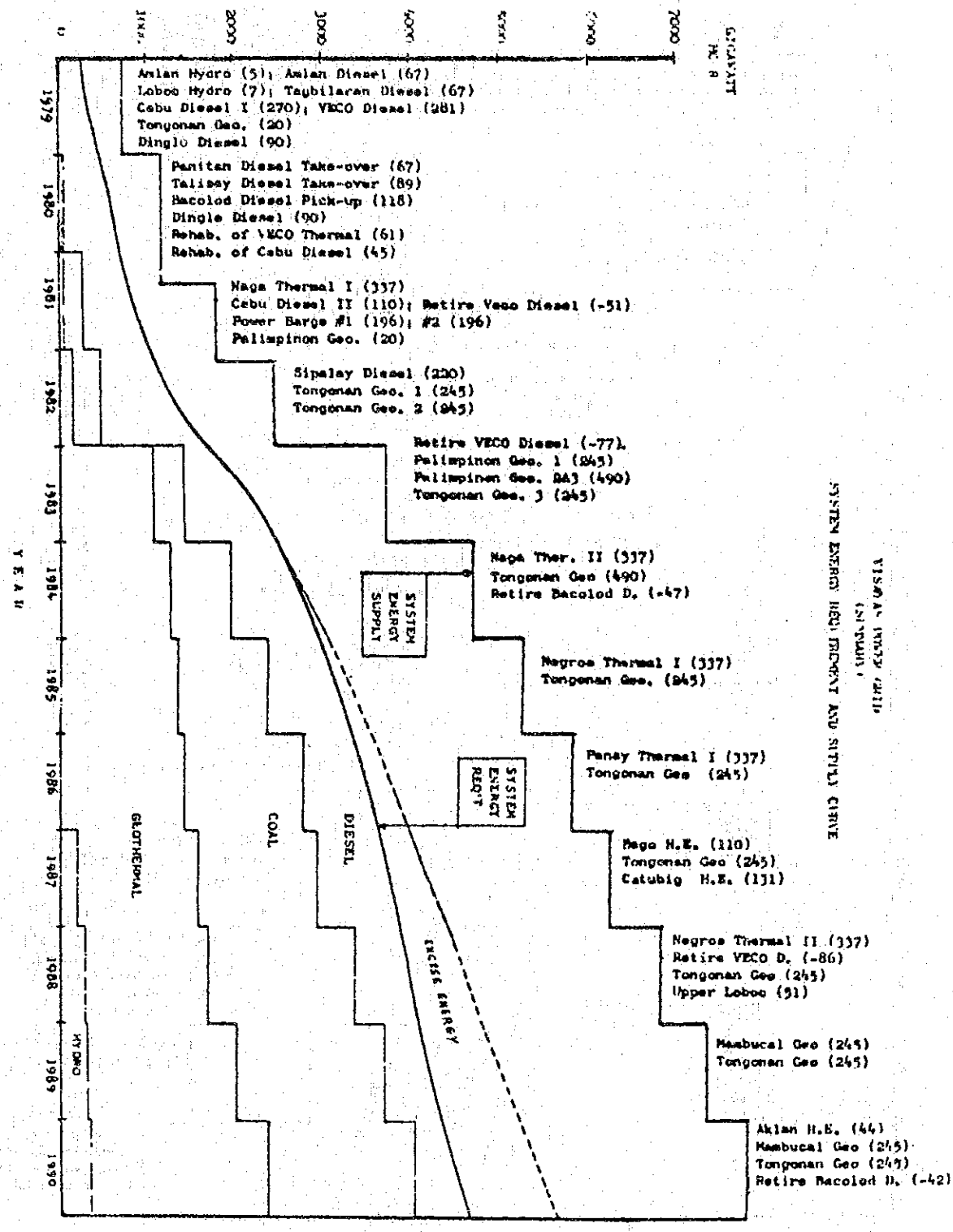


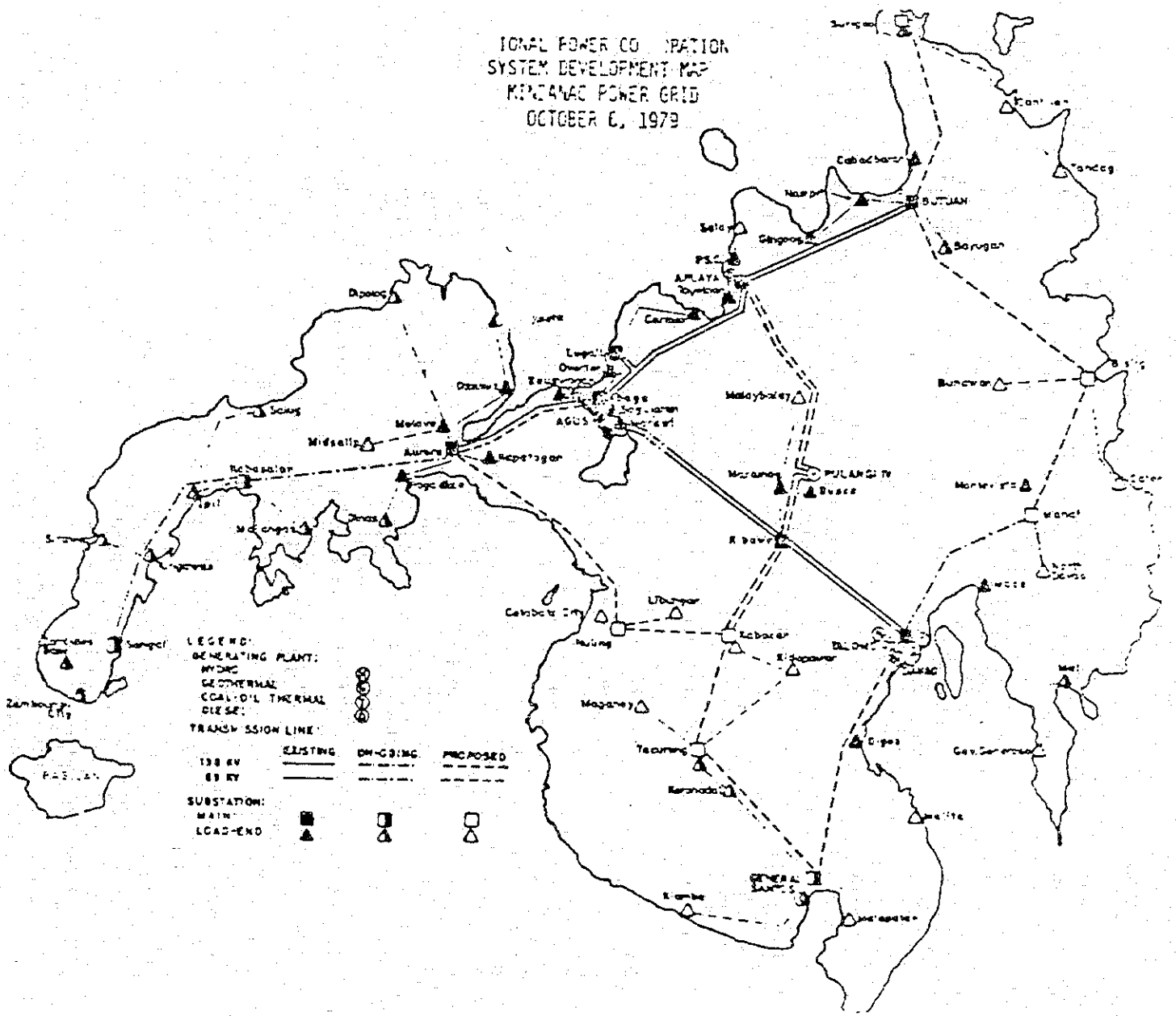
NATIONAL POWER CORPORATION
VISAYAS POWER GRID
DEMAND & ENERGY FORECAST
OCTOBER, 1979

CALENDAR YEAR	CUSTOMER LEVEL DEMAND MW	CUSTOMER LEVEL ENERGY GWH	GENERATION LEVEL DEMAND MW	GENERATION LEVEL ENERGY GWH	L.F. %
ACTUAL					
1974	72.50	330.2	68.0	384.0	64
1975	78.00	361.4	82.1	414.6	58
1976	85.00	381.1	79.7	443.5	63
1977	115.38	431.0	101.0	500.9	57
1978	138.73	622.18	122.2	709.0	66
1974-1978	17.6%	17.2%	15.8%	16.6%	
FORECAST					
1979	146.6	647.2	129.0	733.0	65
1980	177.8	795.1	156.0	899.0	66
1981	221.6	1014.8	204.0	1104.0	62
1982	326.9	1505.1	299.0	1636.0	62
1983	468.8	2239.7	429.0	2401.0	65
1979-1983	33.7%	36.4%	35.0%	35.4%	
1984	547.5	2641.7	500.0	2903.0	66
1985	622.4	3039.1	569.0	3345.0	67
1986	633.1	3275.1	605.0	3604.0	68
1987	704.3	3499.5	644.0	3851.0	68
1988	746.6	3747.7	682.0	4123.0	69
1984-1988	8.1%	9.1%	8.1%	9.2%	
1989	789.8	4010.2	721.0	4412.0	70
1990	833.0	4249.4	761.0	4675.0	70
1989-1990	5.5%	6.0%	5.5%	6.0%	
1974-1990	16.5%	17.3%	16.3%	16.9%	
1979-1990	17.1%	18.7%	17.5%	18.3%	

SPD - CORPLAN
10-16-79/tgi


MEGAWATT
200
400
600
800
1000
1200
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Amlan Hydro (2x0.4); Amlan Diesel (2x5.5)
Loboc Hydro (3x0.4); Tagbilaran Diesel (2x5.5)
Cebu Diesel (6x7.3); VECO Diesel pick-up (49.3)
Tongonan Geo. (1x3)
Dingle Diesel (2x7.3)
Panitan Diesel Take-over (11)
Talisay Diesel Take-over (14.6)
Bacolod Diesel pick-up (22.45)
Dingle Diesel (2x7.3)
Rehab. of VECO Ther. (10)
Rehab. of Cebu Diesel I (7.3)
Naga Thermal 1 (55)
Cebu Diesel II (3x18); Retire Veco Diesel (-9)
Palimpinon Geo. (2x1.5)
Power Barge #1 (4x8); #2 (4x8)
Sipalay Diesel (2x18)
Tongonan Geo. 1 (37.5)
Tongonan Geo. 2 (37.5)
Retire VECO Diesel (-13.5)
Palimpinon Geo. (1x37.5)
Palimpinon Geo. (2x37.5)
Tongonan Geo. 3 (37.5)
Naga Ther II (55)
Tongonan Geo (2x37.5)
Retire Uncoiled D. (-9)
Negros Thermal I (55)
Tongonan Geo. (1x37.5)
Panay Thermal I (55)
Tongonan Geo. (1x37.5)
Bago H.E. (60)
Tongonan Geo. (1x37.5)
Catubig H.E. (30)
Negros Thermal II (55)
Retire VECO D. (-15)
Tongonan Geo. (1x37.5)
Upper Loboc (1x17.5)
Mambucal Geo (1x37.5)
Tongonan Geo (1x37.5)
Aklan H.E. (20)
Mambucal Geo. (1x37.5)
Tongonan Geo. (1x37.5)
Retire Bacolod D. (-8)
TOTAL INSTALLED CAPACITY
SYSTEM PEAK DEMAND
EFFECTIVE CAPACITY
PROJECTED 20% RESERVE CAPACITY
EXCESS POWER
VISAYAS POWER GRID
(SUMMARY)
SYSTEM PEAK DEMAND AND CAPABILITY CURVE


Amlan Hydro (5); Amlan Diesel (67)
Loboc Hydro (7); Taybilaran Diesel (67)
Cebu Diesel I (270); VECO Diesel (281)
Tongonan Geo. (20)
Dinglo Diesel (90)
Panitan Diesel Take-over (67)
Talisay Diesel Take-over (89)
Bacolod Diesel Pick-up (118)
Dingle Diesel (90)
Rehab. of VECO Thermal (61)
Rehab. of Cebu Diesel (45)
Naga Thermal I (337)
Cebu Diesel II (110); Retire Veco Diesel (-51)
Power Barge #1 (196); #2 (196)
Palimpinon Geo. (20)
Sipalay Diesel (220)
Tongonan Geo. 1 (245)
Tongonan Geo. 2 (245)
Retire VECO Diesel (-77)
Palimpinon Geo. 1 (245)
Palimpinon Geo. 2&3 (490)
Tongonan Geo. 3 (245)
Naga Ther. II (337)
Tongonan Geo (490)
Retire Bacolod D. (-47)
Negros Thermal I (337)
Tongonan Geo. (245)
Panay Thermal I (337)
Tongonan Geo (245)
Mego H.E. (110)
Tongonan Geo (245)
Catubig H.E. (131)
Negros Thermal II (337)
Retire VECO D. (-86)
Tongonan Geo (245)
Upper Loboc (91)
Mambucal Geo (245)
Tongonan Geo (245)
Amlan H.E. (44)
Mambucal Geo (245)
Tongonan Geo (245)
Retire Bacolod D. (-42)
SYSTEM ENERGY SUPPLY
SYSTEM ENERGY REQ'T.
EXCESS ENERGY
GEOTHERMAL
COAL
DIESEL
HYDRO
YEAR
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990


IONAL POWER CO PATION
SYSTEM DEVELOPMENT MAP
MINDANAO POWER GRID
OCTOBER 6, 1979
LEGEND:
GENERATING PLANT:
HYDRO
GEOTHERMAL
COAL/OIL THERMAL
DIESEL
TRANSMISSION LINE:
EXISTING
ON-GOING
PROPOSED
138 KV
69 KV
SUBSTATION:
MAIN
LOAD-END
BUTUAN
PULANGI IV
AGUS

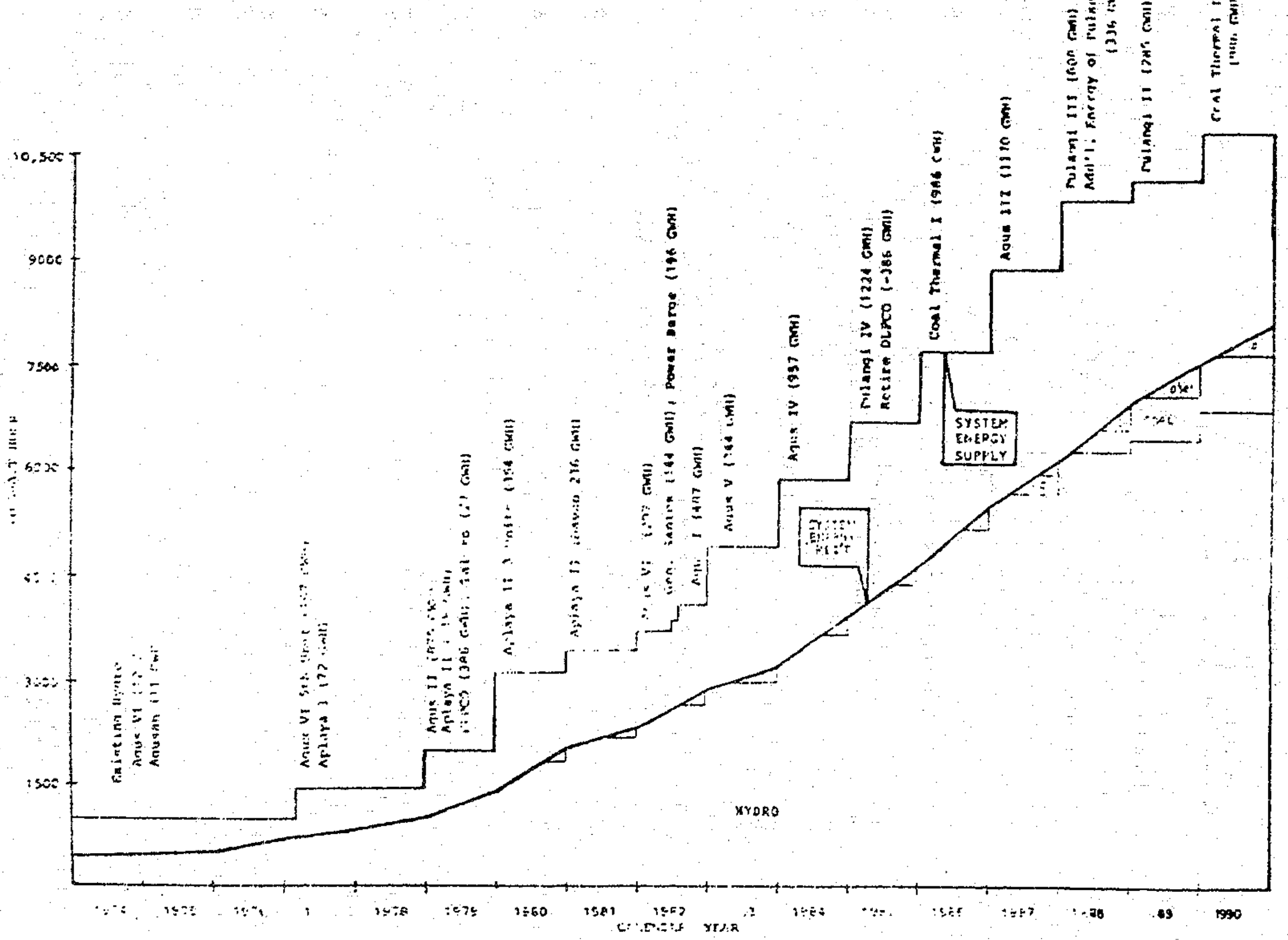
NATIONAL POWER CORPORATION
MINDANAO POWER GRID
DEMAND & ENERGY FORECAST
AUGUST, 1979

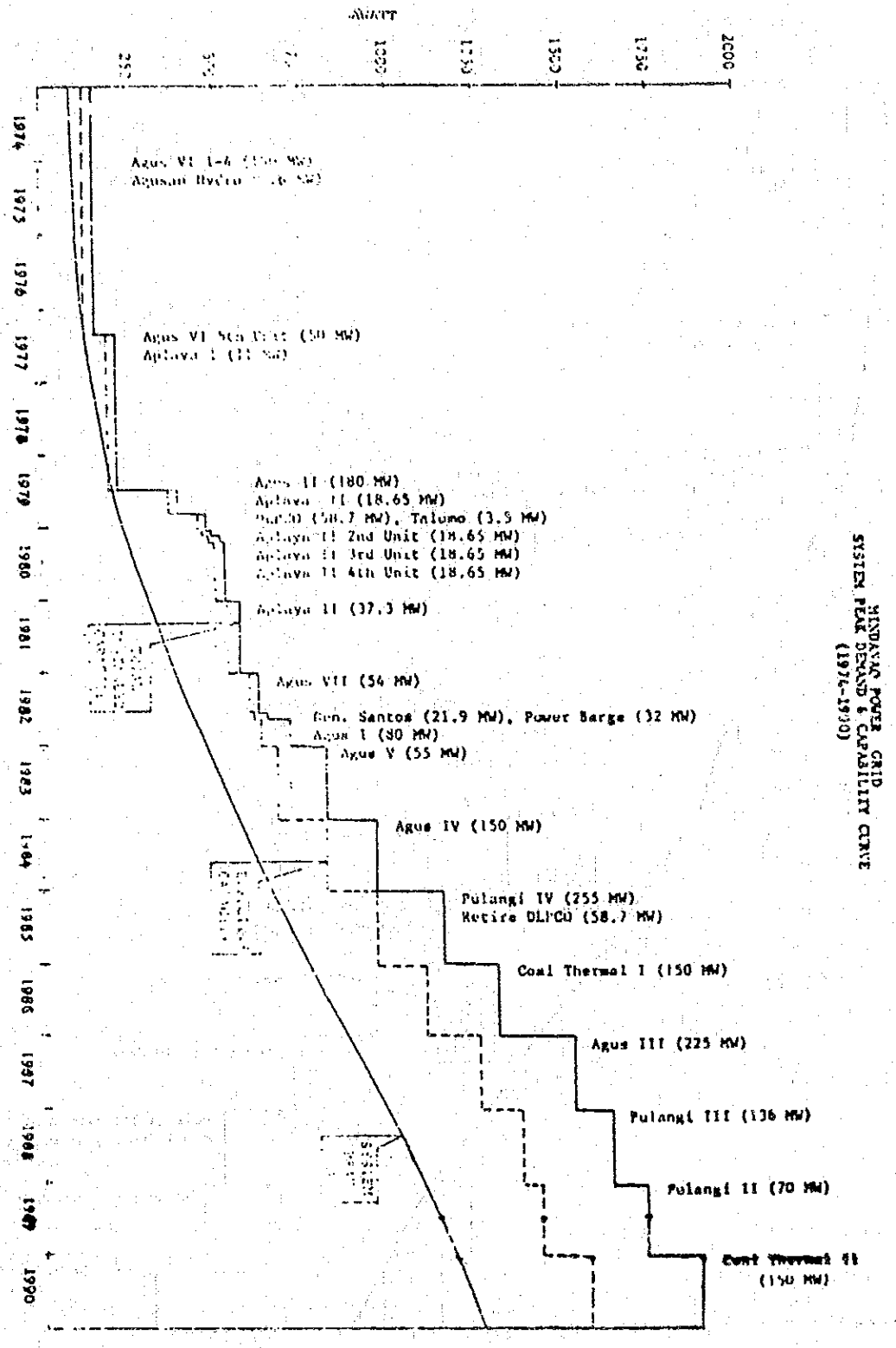
CALENDAR YEAR	CUSTOMER LEVEL DEMAND MW	CUSTOMER LEVEL ENERGY GWH	GENERATION LEVEL DEMAND MW	GENERATION LEVEL ENERGY GWH	L.F. %
ACTUAL					
1969	83	429	74	441	68.0
70	95	476	85	488	65.5
71	117	508	1[illegible]	524	57.5
72	127	527	113	552	55.8
73	142	652	127	683	61.4
1969-1973	14.4%	11.0%	14.5%	11.6%	
1974	134	691	[illegible]20	714	67.9
75	160	7[illegible]6	143	780	62.3
76	189	957	169	990	6619
77	236	1101	211	1131	61.2
78	254	1265	227	1327	66.7
1974-1978	17.3%	16.3%	17.3%	16.8%	
FORECAST					
1979	268	1365	239	1437	68.6
80	377	1951	336	2051	69.7
91	427	2202	381	2318	69.4
82	554	2770	4[illegible]	2916	67.4
83	612	3063	546	[illegible]224	67.4
1978-1983	19.2%	19.3%	19.2%	19.4%	
1979-1983	22.9%	22.4%	22.9%	22.4%	
1984	740	3741	661	3938	68.0
85	858	4376	766	4606	68.6
86	1005	5196	897	5469	69.6
87	1115	5833	996	6140	70.4
88	1231	6621	1[illegible]99	6969	72.4
1983-1988	13.6%	15.3%	13.6%	15.3%	
1984-1988	13.6%	15.[illegible]%	13.6%	15.3%	
1989	1325	7[illegible]9[illegible]	1[illegible]83	7577	73.1
99	1434	7796	1763	8[illegible]11	73.3
1983-1990	12.7%	14.1%	12.7%	14.1%	
1984-1990	11.4%	12.[illegible]%	11.[illegible]%	12.8%	
1978-1990	15.4%	16.3%	15.4%	16.3%	
[illegible]79-1990	16.3%	17.0%	16.3%	17.0%	

NOTE: 1. Diversity Factor - 1.12
2. Energy Loss - 5.0%
3. SPPCO Energy Generation Included

FIG. 10

SYSTEM ENERGY REQUIREMENT AND SUPPLY CURVE
(1974-1990)





MINDANAO POWER GRID
SYSTEM PEAK DEMAND & CAPABILITY CURVE
(1976-1990)

PRELIMI
GEOTHER
IN THE
PHILIPP

JAPAN INTE
AGENCY

MAINIT - BONTOC : ★★★★	
RELATED TO	Qt. volcanism - Mioc. plutonism
RESERVOIR	Metavolcanics
T°C RANGE	200-230°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 5 g/l
SIZE	Medium
DISPOSAL	Reinjection
LOGISTICS	Difficult
POWER Mkt.	Good

BATONG-BUHAY : ★★★★★	
RELATED TO	Qt.volcanism-Mioc.plutonism
RESERVOIR	Metavolcanics
T°C RANGE	220-250°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 12g/l
SIZE	Medium
DISPOSAL	Reinjection
LOGISTICS	Difficult
POWER Mkt.	Good

A C U P A N : ★★	
RELATED TO	Qt.volcanism - Mioc. plutonism
RESERVOIR	Metavolcanics
T°C RANGE	200-220°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 3.5g/l
SIZE	Undefined
DISPOSAL	Reinjection
LOGISTICS	Fairly good
POWER MKT	Very good

D A K L A N : ★★★★	
RELATED TO	Qt.volcanism - Mioc. plutonism
RESERVOIR	Metavolcanics &/or Mio. clastics
T°C RANGE	210-230°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 11g/l
SIZE	Small to medium
DISPOSAL	Reinjection
LOGISTICS	Good
POWER Mkt.	Very good

MONTELAGO : ★★★	
RELATED TO	Plio-Qt. Flss. & Centr. basic volcanism
RESERVOIR	Tert. sediments or Pre-Jur. basement
T°C RANGE	180-220°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 8g/l
SIZE	Undefined
DISPOSAL	Into the sea
LOGISTICS	Very good
POWER Mkt.	Small if not interconnected

BUENAVISTA : ★	
RELATED TO	Centr.type Plio. volcanism
RESERVOIR	Miocene andesites
T°C RANGE	< 200°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 0.7 g/l
SIZE	Small
DISPOSAL	Into the sea
LOGISTICS	Very gona
POWER Mkt.	Very good

GEOLOGICAL LEG

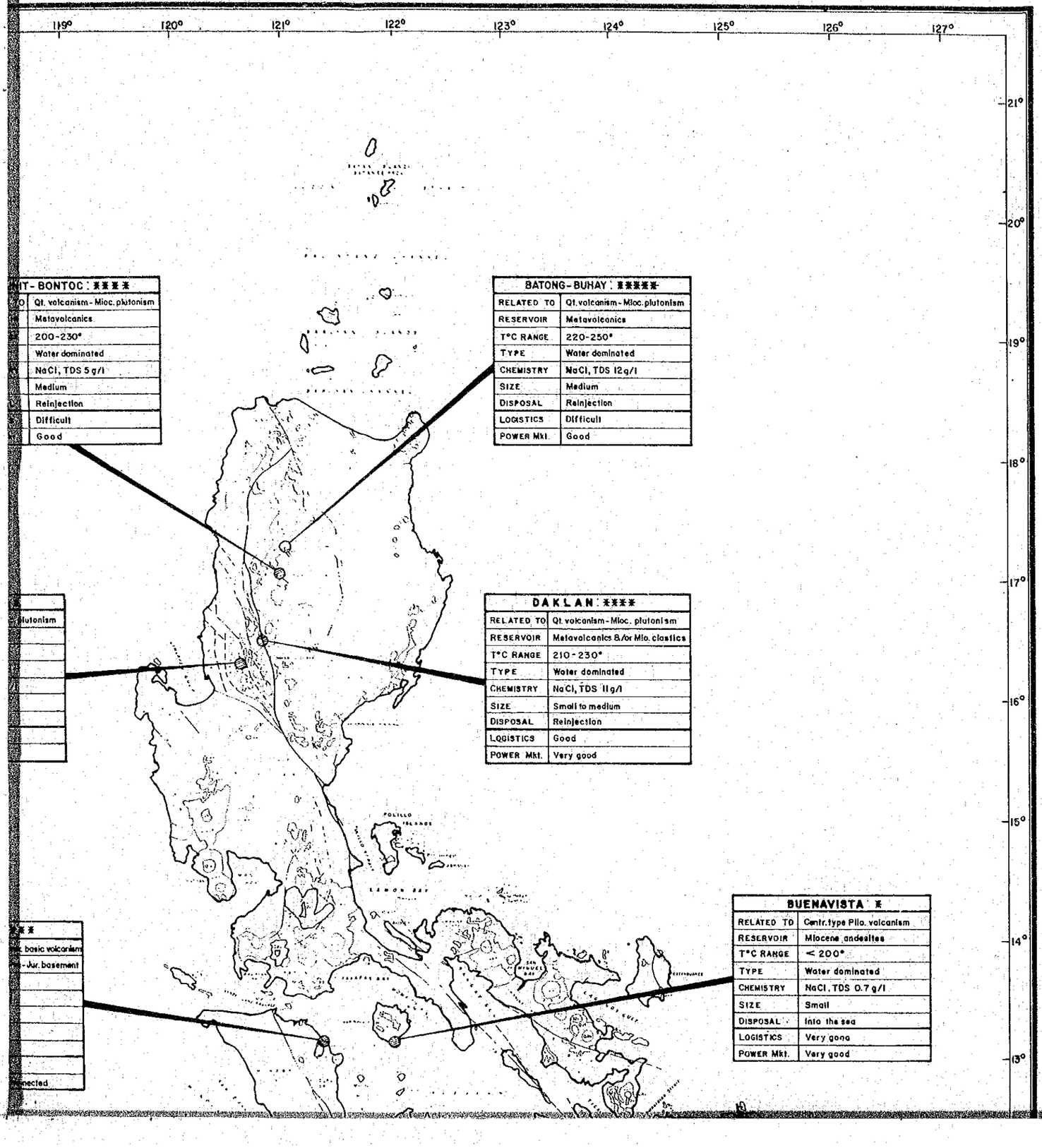
- QAV — QUATERNARY
- QVP — PLIOCENE
- QV — QUATERNARY
- NI — NEOGENE

PROSPECT EVA

- ★★★★★
- ★★★★
- ★★★
- ★★
- ★

PRELIMINARY SURVEY FOR THE GEOTHERMAL DEVELOPMENT PLAN IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY



MT-BONTOC : ****	
70	Qt. volcanism - Mioc. plutonism
	Metavolcanics
	200-230°
	Water dominated
	NaCl, TDS 5 g/l
	Medium
	Reinjection
	Difficult
	Good

BATONG-BUHAY : *****	
RELATED TO	Qt.volcanism - Mioc.plutonism
RESERVOIR	Metavolcanics
T°C RANGE	220-250°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 12g/l
SIZE	Medium
DISPOSAL	Reinjection
LOGISTICS	Difficult
POWER Mkt.	Good

	plutonism

DAKLAN : ****	
RELATED TO	Qt. volcanism - Mioc. plutonism
RESERVOIR	Metavolcanics &/or Mio. clastics
T°C RANGE	210-230°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 11g/l
SIZE	Small to medium
DISPOSAL	Reinjection
LOGISTICS	Good
POWER Mkt.	Very good

***	
	basic volcanism
	- Jur. basement
	nected

BUENAVISTA *	
RELATED TO	Centr.type Plio. volcanism
RESERVOIR	Miocene andesites
T°C RANGE	< 200°
TYPE	Water dominated
CHEMISTRY	NaCl, TDS 0.7 g/l
SIZE	Small
DISPOSAL	Into the sea
LOGISTICS	Very good
POWER Mkt.	Very good

GEOLOGICAL LEGEND

QAV	QUATERNARY	– Active volcano with eruption and/or activity since 1616
QVP	PLIOCENE QUATERNARY	– Volcanic Plain or volcanic piedmont deposit
QV		– Non-active cone; also dacitic or andesitic plug
NI	NEOGENE	– Largely Intra-Miocene quartz diorite, mostly batholiths and stocks

– – – – – – – Geologic contact

– – – – – – – High angle fault, dashed where inferred

– – – – – – – Normal fault, hachures on downthrown side

PROSPECT EVALUATION:

*****	Very good potential
****	Good potential
***	Medium potential
**	Mediocre potential
*	Insufficient potential

CHEMISTRY	NaCl, TDS 8g/l
SIZE	Undefined
DISPOSAL	Into the sea
LOGISTICS	Very good
POWER Mkt.	Small if not interconnected

SIZE	Small
DISPOSAL	Into the sea
LOGISTICS	Very good
POWER Mkt.	Very good

BALATUKAN ⁑	
RELATED TO	Plio-Ql. Fiss. & Centr. basic volcanism
RESERVOIR	Miocene diabase
T°C RANGE	<200°
TYPE	Undefined
CHEMISTRY	$NoHCO_3$, TDS 0.7 g/l
SIZE	Small
DISPOSAL	Into the sea
LOGISTICS	Difficult
POWER Mkt.	Very good

⁑⁑ ------ Mediocre

⁑ ------ Insuffici

50 0 SC

PALAWAN PASSAGE

PALAWAN

BORNEO

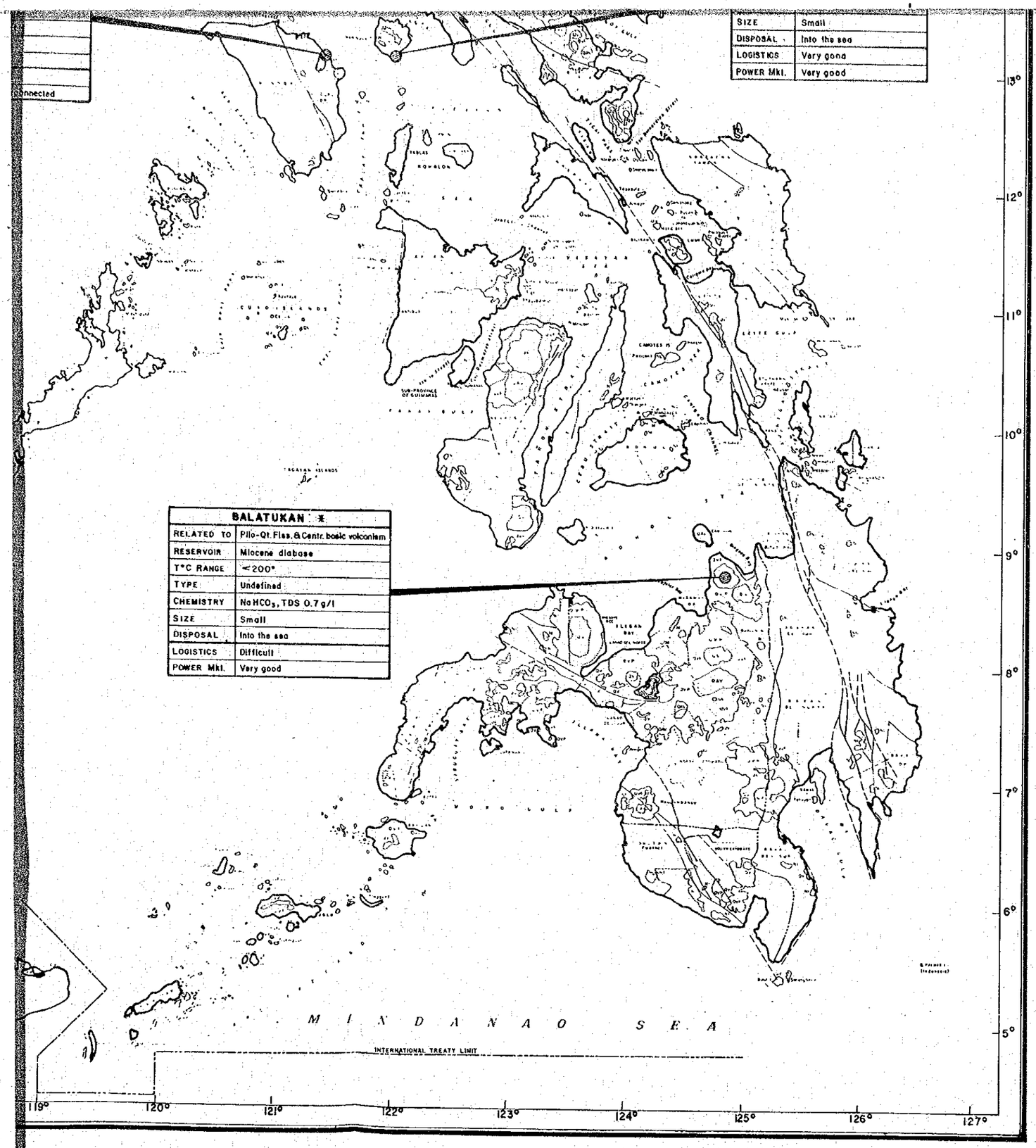
MINDANAO SEA

INTERNATIONAL TREATY LIMIT

13° 12° 11° 10° 9° 8° 7° 6° 5°

116° 117° 118° 119° 120° 121° 122° 123° 124° 125° 126° 127°

Fig 3.5
GEOTHERM
SYNOPTIC
(after BED's



** ------ Mediocre potential

* ------ Insufficient potential

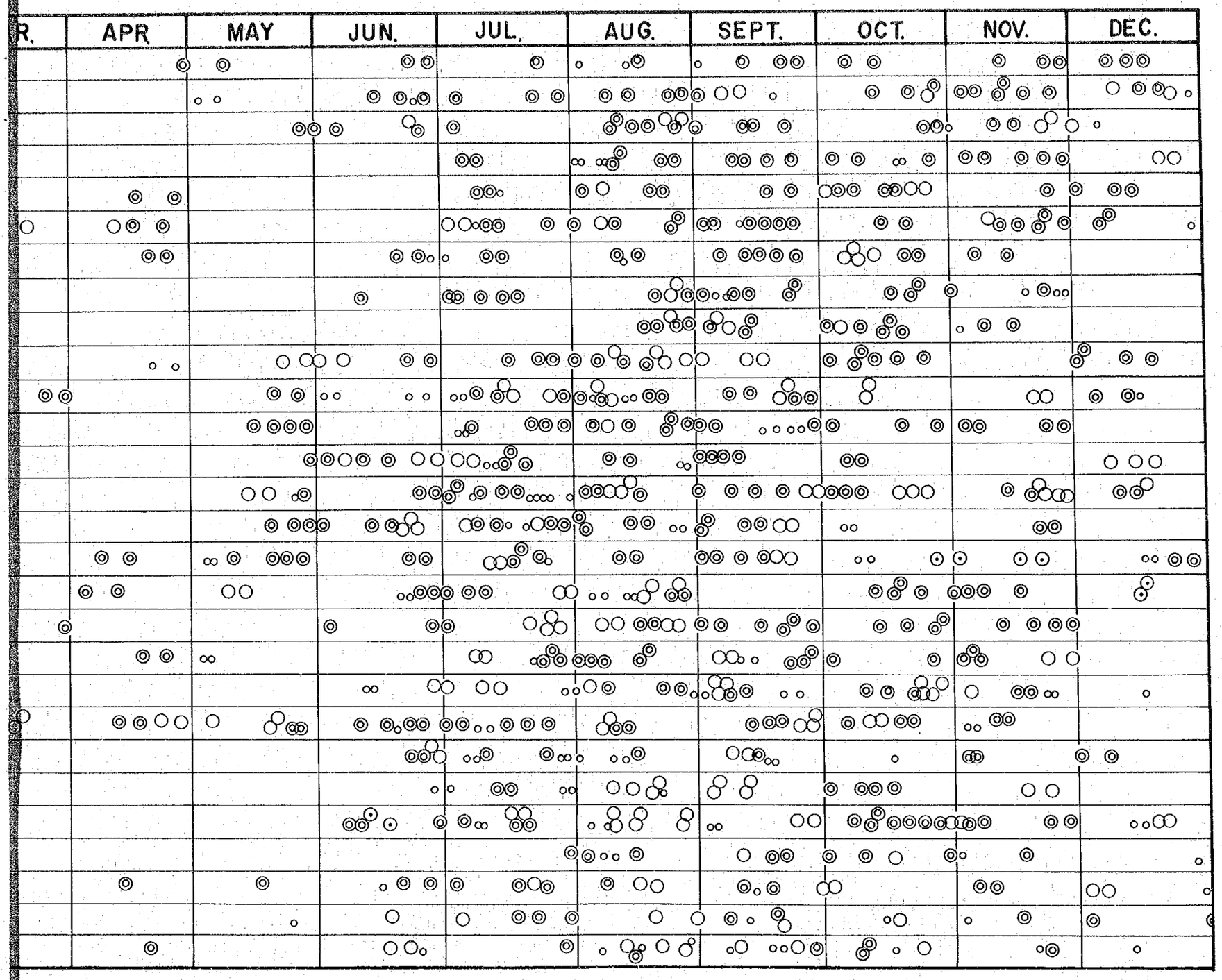
SCALE 1:4,000,000

50 0 50 100 200 KM

Fig 3.5
GEOTHERMAL PROSPECTS
SYNOPTICAL DATA MAP
(after BED's data) (February, 1979)

YEAR	JAN.	FEB.	MAR.	APR	MAY	JUN.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
1951												
1952												
1953												
1954												
1955												
1956												
1957												
1958												
1959												
1960												
1961												
1962												
1963												
1964												
1965												
1966												
1967												
1968												
1969												
1970												
1971												
1972												
1973												
1974												
1975												
1976												
1977												
1978												

Fig 3.6 STATISTICS OF WIND VELOCITY DUE TO TROPICAL CYCLONES



THE CATEGORIES OF TROPICAL CYCLONES ARE CLASSIFIED BY THE PHILIPPINE WEATHER BUREAU

- o TROPICAL DEPRESSION–MAX WIND SPEED WITHIN THE DISTURBANCES UP TO 61 KILOMETERS PER HOUR (33 KNOTS) OR 38 MILES PER HOUR
- ○ TROPICAL STORM–MAX WIND SPEED WITHIN THE DISTURBANCES RANGES FROM 63–87 KILOMETERS PER HOUR (47 KNOTS) OR FROM 39–54 MILES PER HOUR
- ⊙ SEVERE TROPICAL STORM–MAX WIND SPEED WITHIN THE DISTURBANCE RANGES FROM 88–117 KILOMETERS PER HOUR (48–63 KNOTS) OR FROM 55–74 MILES PER HOUR
- ◎ TYPHOON–MAX WIND SPEED WITHIN THE DISTURBANCES EXCEEDS 118 KILOMETERS PER HOUR (64 KNOTS) OR 74 MILES PER HOUR

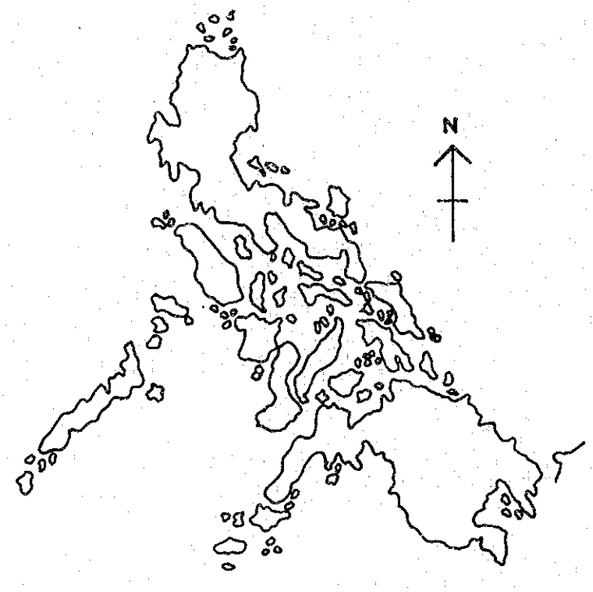


Fig 3.6 STATISTICS OF WIND VELOCITY DUE TO TROPICAL CYCLONES (after BED's data)

資　料　4

DAKLAN 地域資料

資料 4.1　Preliminary Assessment of Daklan-Bokod(pp.14)

Fig.4.2.1　Geological Map

Fig.4.2.2　Geological Sections

Fig.4.2.3　Hydrochemical Map

Fig.4.2.4　Location of Vertical Electrical Soundings

Fig.4.2.5.1 Electro-stratigraphic Sections

Fig.4.2.5.2　- do -

Fig.4.2.5.3　- do -

Fig.4.2.6　Contour Lines of the Top of the Conductive Unit

Fig.4.2.7　Contour Lines of the Top of the Registive Basement

Fig.4.2.8　DGHI Gradient Hole

Fig.4.2.9　Thermal Gradient v s. Resistvity

Fig.4.3　Route Map in Daklan Area

Fig.4.4　Aero-Magnetic Map

Fig.4.5　Geological Map of Bokod Area

資料 4. 1

REPUBLIC OF THE PHILIPPINES

PHILIPPINE ITALIAN TECHNICAL COOPERATION
ON GEOTHERMICS
STAGE-II

ANNEX-4

PRELIMINARY ASSESSMENT
OF
DAKLAN-EKOD
(BENGUET PROVINCE)

Bureau of Energy Development
Ministry of Energy

ELC-Electroconsult, S.p.A.
Milano-Italy

Manila, February 1979
PHILIPPINES

1 SUMMARY AND CONCLUSIONS

The Daklan area (Bokod municipality, Benguet province) is made of a set of Quaternary volcanic rocks, resting on top of the Cretaceous-Tertiary basement complex of the Cordillera Central.

The thermal activity is characterized by a central manifestation of steam and gas associated with a halo of hydrothermal alteration, by peripherical leakages of hot Na-chloride waters, and by scattered warm dilute springs.

The volcanic cover shows to be a suitable cap-rock, while the underlying basement of rigid rocks affected by multiple faulting, is likely to have acquired good secondary permeability. Such a favourable geological setting appears to contain a geothermal system, whose temperature, according to the geothermometers provided by the Na-chloride springs, ranges between 200 and 250°C.

The size of the thermal area, due to still incomplete field geological and geochemical surveys; remains somewhat undefined but looks to be not less than 10 sq. km, sufficient therefore to assure the existence of a potentially exploitable geothermal field. A programme of detailed and deeper exploration is here proposed to confirm the preliminary assessment.

2 INTRODUCTION

2.1 General

The Daklan geothermal area, situated in the municipality of Bokod (Benguet Province) was included in the inventory only at a later date. This was due both to a lack of basic information and to the already great number of areas to be preliminarily assessed, much larger than originally foreseen. However, the socio-political and logistical difficulties which gradually surfaced in the last months, and which may, at least temporarily, prevent the exploration of two of the best prospects (Batong-Buhay) and Mainit-Bontoc), made it pressing to look for possible alternatives. Among the new areas examined, Daklan showed to be the most attractive and worth of being deeply investigated. Due to the short time available the preliminary assessment has been necessarily based on a more limited information than for the other areas, and consequently the present report is less detailed.

2.2 Work Performed

The work performed consisted essentially of (a) inventory and mapping of the thermal manifestations, (b) geological reconnaissance, (c) sampling and analysis of the thermal manifestations. Field work was started in December 1978 for a period of one week and was resumed in January 1979. Very little information could be gathered from the existing literature and only of a general nature.

2.3 Location and Access

The Daklan area is situated within the municipality of Bokod, which lies in the Benguet province, approximately 60 km road distance ENE of Baguio City.

The name Daklan is derived from barrio Daklan, lying within the Bokod municipality and sited next to the main thermal manifestations. The approximate physical limits of the area are the Agno river on the west and on the north, the Bokod river on the east and on the south (See Plate 0701). The above boundaries include an area of approximately 70 sq. km, with a topography relatively smooth only in its center (where barrio Daklan is located), but rather rugged in all its remaining territory. The lowest part has an elevation around 800 meters, while the highest reliefs reach over 1,600 meters. The area is easily accessible from Baguio, through Ambuklao dam, with mostly paved road up to Ambuklao and dirt road from there on. Shortly, a new access will be made available from the north, upon rehabilitation of the road linking Bokod with Buguias passing through the municipality of Kabayan. Some jeepable trails exist within the area and the limited agricultural development will ease future operations.

2.4 Power Market

The Daklan area is situated only 10 km aerial distance from the Ambuklao 75 MW hydropower plant and future geothermal power plant could be therefore easily tied in the northern Luzon electrical grid.

3 DESCRIPTION OF THE FINDINGS

3.1 Geology

The reconnaissance survey so far carried out allows to make the following general geological outline (See Figure 1 and Plate 0701). The Daklan area lies within a zone of Quaternary volcanic activity, which generated a fairly large amount of lavas and pyroclasts and ended with the uplifting of a cluster of small lava domes. The general character of the volcanic products is acidic (andesitic to dacitic type) and pyroclasts appear to prevail largely over lavas. The lavas show a porphyritic structure, with phenocrysts of plagioclase and amphibole in a cryptocrystalline matrix. The volcanics cover an area of approximately 30 sq. km, resting on top of the Cretaceous-Tertiary basement complex. Their thickness is still undefined, but is likely to be, at least in the central portion of the area, of some hundreds of meters. The basement complex is constituted by slightly metamorphosed intermediate to basic lava flows (metavolcanics), overlain by a Miocenic sequence of coarse clastics. Both the metavolcanics and the clastics were intruded during the Miocene by batholiths and stocks of granodioritic or dioritic composition, which extensively outcrop a few kilometer to the west and south of the thermal zone. The area is comprised between faults of the N-S regional system, which locally have a NNE trend. Faults belonging to a WNW-ESE younger cross system appear to bound the area on the north and on the south. A third structural system, trending NE to ENE, is likely to have played an important role in the uplift of the lava domes and in the final structural setting of the area. The zone of recent volcanic activity appears to occur within a colderic depression with a diameter of about 6 km and with rims not well defined. Within this depression the domes cluster constitutes a structural high with a surface of about 4 sq. km.

3.2 Hydrogeology

Hydrogeologically, the volcanic cover and the underlying basement represent two well defined units. The volcanics appear to be on the whole impervious, due to the incompetent character of the pyroclasts, while the more rigid basement rocks, affected by the multiple faulting, are likely to have developed a good secondary permeability.

The combination of these two hydrogeological units provides a favorable setting for the occurrence of a geothermal system, the former acting as a sealing cap-rock, the latter as a reservoir rock and a suitable structure for deep vertical circulation.

3.3 Thermal Manifestations

The main thermal manifestations are represented by a solfataric field, situated at the eastern foot of the group of lava domes. The thermal activity consists of steam condensate and gas emission, accompanied by a wide halo of rock alteration. The highest measured temperature is 86°C, which indicates that steam condenses very close to the surface. About 6 main issue points can be observed, whose temperature and characteristics (such as mud colour) vary according to the rate of mixture with surface water. A deep mud pot inside a sinter cone, discharging abundant gas, is also present. The gases are mainly CO_2 and H_2S. The present activity occupies an area of about 80 x 50 meters, but the halo of extremely kaolinized rocks (the porphyritic lava) is much larger.

The other manifestations are constituted by hot and warm springs, scattered in a radius of approximately 2 km around the solfataric field. The hottest ones (60 to 79°C) are highly saline and emerge along deep river cuts, with moderate flow. The other ones, with temperatures in the range 36-39°C, are rather dilute, have low flow and emerge at higher elevation and closer to the solfataric field than the former ones.

3.4 Chemistry of the Manifestations

As already pointed out, the main manifestations discharge gas and steam condensate (See Table I and Figure 2). The steam mixes near surface and also on the surface with rain water and the resulting chemical

composition is that of a very acid water (pH ranges between 1.6 and 2.8), with the anion SO_4 as the main constituent (between 7 and 14 meq/l). The water also contains minor amounts of Ca and Na and variable amounts of SiO_2 and, as it could be expected, ammonia in considerable concentrations (19-26 ppm).

The salty hot springs show instead a neutral pH and a typical Na chloride composition, containing 5-10 g/l of Na Cl, the hottest being the most concentrated. As secondary constituents are Ca and HCO_3, while sulfate is here rather low. The ammonium content was determined in the order of 0.6 ppm. Finally, the lukewarm spring discharge a dilute Ca-bicarbonate water and have a neutral pH.

No.	TYPE	t°C	pH	COND	Na	K	Ca	Mg	Cl	SO_4	NO_3	$F_{(1)}$	Li	As	B	SiO_2	H_2S
1	Fum. Cond.	51	2.69	879	12.5 0.54	3.48 0.09	42.5 2.12	3.80 0.31	18.4 0.52	382 7.95	ND –	ND –	ND –	ND –	0.06	213	NA
2	– do –	56	1.58	13182	19.0 0.83	29.6 0.76	4.34 0.22	10.7 0.88	113 3.19	645 13.43	ND –	ND –	ND –	ND –	ND	406	25.7 1.42
3	– do –	80	2.27	1263	2.23 0.10	2.26 0.06	24.4 1.22	2.85 0.23	28.4 0.80	513 10.68	ND –	ND –	ND –	ND –	ND	218	19.2 1.06
4	– do –	36	2.07	3760	16.8 0.73	4.00 0.10	42.5 2.12	3.92 0.32	28.4 0.80	527 10.97	ND –	ND –	ND –	0.03 –	ND	259	NA
5	– do –	67	2.68	1453	5.62 0.24	4.00 0.10	28.9 1.44	6.42 0.53	14.2 0.40	517 10.76	ND –	ND –	ND –	ND –	ND	214	NA
6	– do –	86	2.81	1606	10.4 0.45	3.13 0.08	82.5 4.12	8.32 0.68	14.2 0.40	460 9.58	ND –	ND –	ND –	ND –	ND	109	0.12 0.01
7	Cold Spring	26	2.60	1774	8.31 0.36	2.78 0.07	82.5 4.12	13.2 1.09	18.4 0.52	519 10.80	ND –	ND –	ND –	ND –	ND	114	NA
8	Spring	39	6.63	659	31.9 1.39	5.39 0.14	100 4.99	17.8 1.46	9.92 0.28	57.3 1.19	439 7.19	ND –	ND –	ND –	ND	132	NA
9	River	24	7.65	171	10.2 0.44	1.59 0.04	21.7 1.08	3.74 0.31	10.6 0.30	16.4 0.34	98.8 1.62	ND –	ND –	ND –	ND	59.9	NA
10	Spring	36	6.92	625	34.6 1.50	6.67 0.17	86.2 4.30	19.8 1.63	9.93 0.28	17.3 0.36	464 7.60	ND –	ND –	ND –	0.11	120	NA
11	– do –	79	7.78	15463	3650 158.76	456 11.66	197 9.83	22.0 1.81	6327 178.44	60.2 1.25	536 8.78	ND –	8.77 1.26	5.50 0.37	93.6	171	0.59 0.03
12	River	25	8.43	600	41.5 1.80	3.45 0.09	50.5 2.52	13.5 1.11	55.3 1.56	14.3 0.30	252 4.13	ND –	0.09 0.01	0.06 –	0.63	38.7	NA
13	Spring	40	6.54	583	30.4 1.32	3.27 0.08	74.1 3.70	18.9 1.55	9.93 0.28	65.2 1.36	336 5.51	ND –	ND –	ND –	ND	118	NA
14	– do –	40	6.82	600	27.7 1.20	3.33 0.08	85.2 4.25	16.6 1.36	14.2 0.40	69.0 1.45	323 5.29	ND –	ND –	ND –	0.11	118	NA

TABLE I

Chemical Analysis

No.	TYPE	t °C	pH	COND	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	Li	As	B	SiO_2	NH_4
15	Spring	71	7.30	8700	1690 73.51	322 8.23	237 11.83	20.8 1.71	3227 91.01	101 2.10	474 7.77	ND -	5.99 0.86	0.80 0.05	45.4	121	NA
16	Cold Spring	20	5.64	157	8.46 .37	1.26 0.03	13.9 0.69	2.20 0.18	14.2 0.40	26.5 0.55	44.1 0.72	ND -	ND -	ND -	ND	51.3	NA
17	Spring	34	6.42	634	29.6 1.29	3.88 0.10	77.8 3.88	27.3 2.24	15.6 0.44	11.4 0.24	473 7.75	ND -	ND -	ND -	ND	124	NA
18	River	18	7.53	177	9.62 0.42	0.58 0.02	20.9 1.04	6.35 0.52	11.3 0.32	5.47 0.11	130 2.13	ND -	ND -	ND -	0.05	53.7	NA
19	- do -	23	8.09	166	7.23 0.31	0.22 0.01	20.9 1.04	6.24 0.51	11.3 0.32	5.47 0.11	128 2.10	ND -	ND -	ND -	0.11	23.1	NA
20	- do -	19	8.09	281	10.8 0.47	0.36 0.01	36.0 1.80	12.4 1.02	9.93 0.28	2.53 0.05	210 3.44	ND -	ND -	ND -	0.11	36.4	NA
21	Spring	60	6.90	12820	2548 110.80	417 10.68	433 21.61	26.3 2.16	5070 142.97	92.3 1.92	521 8.54	ND -	10.4 1.50	3.25 0.22	73.3	114	NA
22	- do -	77	6.62	11013	2242 97.53	362 9.27	296 14.77	20.6 1.70	4255 119.99	109 2.27	399 6.54	ND -	9.08 1.31	2.50 0.17	60.8	132	NA
23	River	22	6.80	264	12.7 0.55	2.61 0.07	27.3 1.36	7.30 0.60	7.09 0.20	1.54 0.03	196 3.21	ND -	ND -	ND -	0.29	73.3	NA

Ions concentration expressed in ppm and meq/l
ND - Not detected
NA - Not analyzed

Table I (cont'd)

4 INTERPRETATION OF THE RESULTS

The geological and geochemical data allow to outline a preliminary model for the Daklan geothermal system.

A geothermal reservoir is likely to occur inside the pervious basement rocks, capped by the impervious Quaternary volcanics. Geothermal fluid, which is most probably in the liquid form, is allowed to upflow towards the surface along more permeable vertical structures which can be related to the domes feeding fractures. Boiling takes place on the way up, due to decreased hydrostatic pressure and only steam reaches the surface in the central part of the area. On its margins, however, where the cap-rock is deeply cut be stream beds, some direct leakage from the reservoir takes place. The salty hot springs are likely to represent, in fact, a water with a composition very close to that of the reservoir fluid, though in some of them dilution by surface water has probably occurred.

These springs' water indicates a base temperature, according to the Na/K and Na-K-Ca geothermometers, well above 200°C, while SiO_2 seems to reflect much lower temperatures. It must be said that the springs' small flow and mixing with surface water may have implied appreciable losses of SiO_2 while water was flowing to the surface. The temperature indicated by the other geothermometers appears certainly more reliable, though the availability of only 4 data invites to a certain degree of caution. It should be also observed that the relatively high concentration of magnesium contrasts with high sub-surface temperature. Data are at present insufficient to decide whether this Mg has been picked up through mixing or is an original character of the geothermal fluid. Finally, the remaining lukewarm springs, whose

composition is a dilute Ca-bicarbonate one, denote heating by conduction of shallow fresh waters acid represent therefore a favourable indication of a diffused heat flow.

On the whole, it may be concluded that surface evidence and available data let suppose the existence in Daklan of a medium ($> 200 < 250°C$) temperature geothermal system, of moderate extension, which could have suitable characteristics for commercial exploitation. This will have to be confirmed, however, by additional more detailed exploration.

5 EXPLORATION PROGRAMME

To complete the exploration of the Daklan area up to a point of deciding one deep drilling, the following investigations are envisaged (See Plate 0702):

a) regional and detailed geological and volcanological studies;

b) photogeology;

c) completion of inventory and mapping of thermal manifestations;

d) geochemical and isotopical analysis;

e) georesistivity survey at a semi-detailed level

f) gradient holes

5.1 Geological and Photogeological Studies

Geological studies will be conducted on a sufficiently large zone to allow the proper framing of the Daklan area within the geological and structural context of the region. At the same time, the area directly related to the geothermal system, which can be figured out in about 50 sq. km, will be mapped in detail. The age and history of the volcanic activity will be investigated, in order to establish the sequence of the volcanic phases and build-up a reliable geological model.

The accurate analysis and interpretation of the air photos will help defining the regional and local structures.

5.2 Geochemical and Isotopic Studies

Though a preliminary inventory of the manifestations and their chemical analysis have been already accomplished, a more accurate research of manifestations will be carried out and chemical analyses of water and of solid deposits will be made. A detailed NH_4 survey will be also carried out, as in this type of geothermal area, it represents the most efficaceous measure of detecting steam leakage.

To acquire more information on the general hydrological condition, isotopic analyses both on hot and cold waters will be also carried out.

5.3 Georesistivity Survey

It will be carried out over an area of approximately 40 sq. km, with Schlumberger array, AB/2 - 1.500 meters. Soundings will be executed at 1 km interval, and possibly with closer spacing in the central part of the area.

5.4 Gradient Wells

Approximately 15 wells will be drilled to a depth of 100 to 200 meters, moving outwards from the center of the area. The first locations will be based on present data, while subsequently locations will be decided on the base of gradient and georesistivity results.

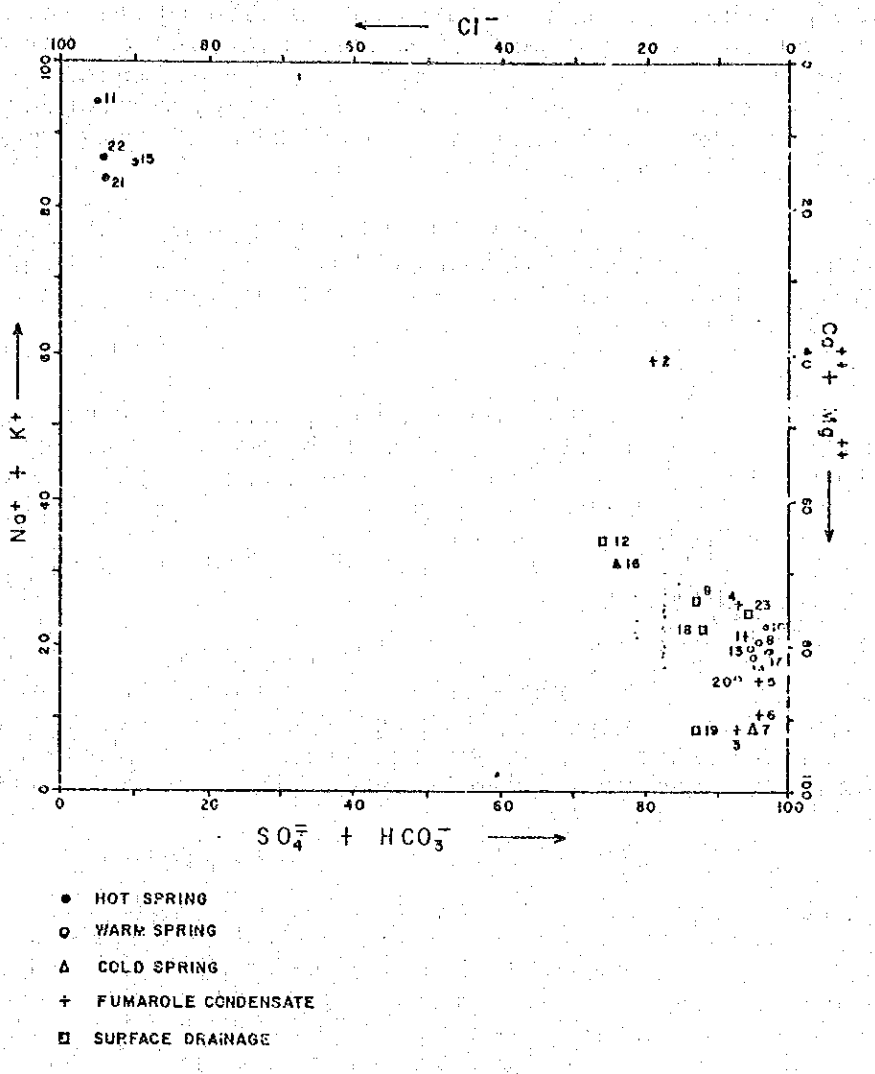


FIG. 2

SQUARE DIAGRAM OF DAKLAN WATERS

120°50'

MAP OF THE PHILIPPINES

INDEX MAP

	Products of Daklan domal complex : hornblende andesite, lahar, pyroclasts	PLIOCENE PLEISTOCENE
	Products of Mount Palaosa and Mount Bugdan	
	Sub-intrusive andesite breccia	
	Hornblende quartz diorite	UPPER MIOCENE
	Volcano-sedimentary complex : sediments and basic-intermediate lavas	OLIGOCENE MIOCENE
	Slightly metamorphosed lavas, sediments and pyroclasts (metavolcanics)	PALEOGENE
	Fault	
	Solfatara or hot spring	
	Boundary of area covered by detailed mapping	
	Trace of geological section (Plate 1103)	

Fig 4.2.1

N

500 0 500 1000 1500 2000M

SCALE: 1:50,000

PHILIPPINE - ITALIAN TECHNICAL COOPERATION PROGRAM - STAGE III

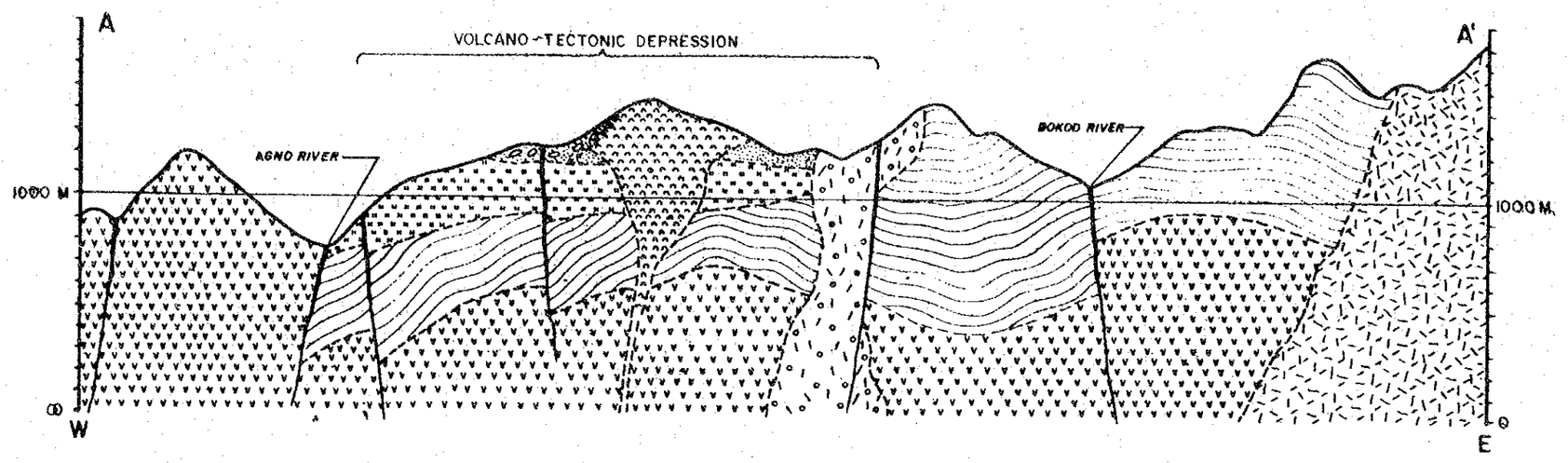
BUREAU OF ENERGY DEVELOPMENT — ELC ELECTROCONSULT

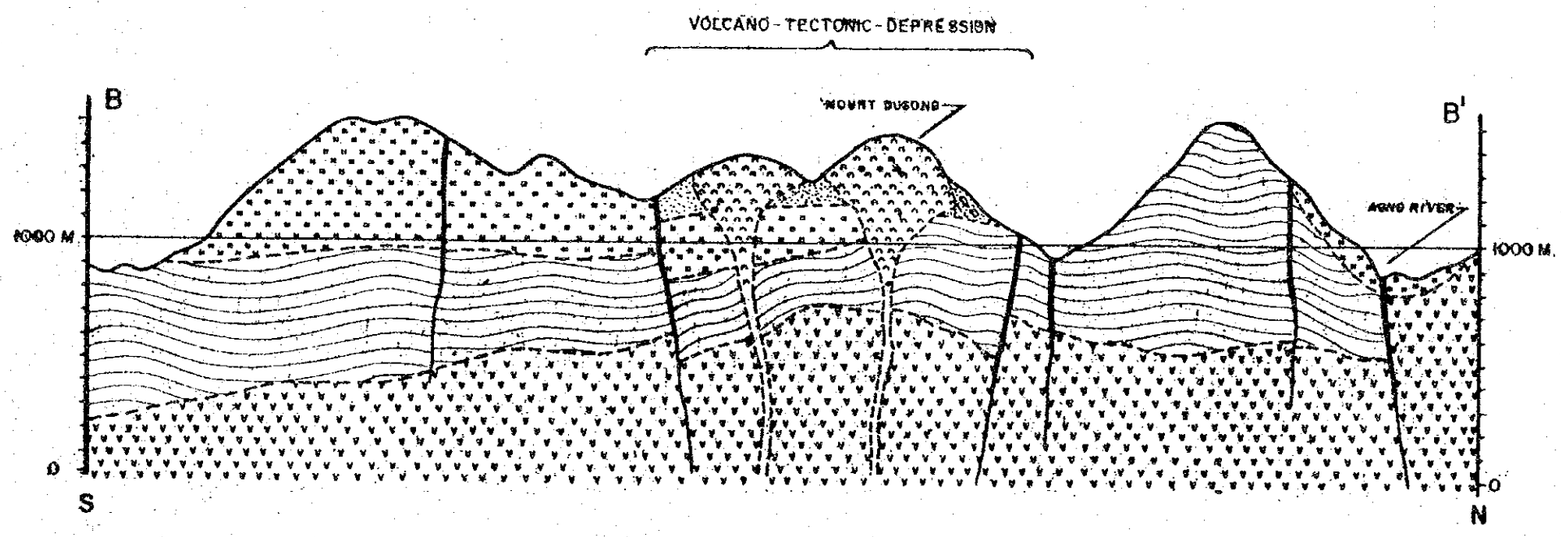
PRE-FEASIBILITY STUDY
DAKLAN - BOKOD (Benguet Province)
GEOLOGICAL SURVEY

GEOLOGICAL MAP

PLATE 1101

DRAWN BY	CHECKED BY:	APPROVED BY:	DATE
E.R. [illegible] CRUZ			MARCH, 1980





EXPLANATION

PLIOCENE-PLEISTOCENE
- Lahar
- Hornblende andesite
- Pyroclasts
- Sub-intrusive andesite breccia

UPPER MIOCENE
- Hornblende quartz-diorite

OLIGOCENE MIOCENE
- Andesitic basaltic flows
- Volcano sedimentary formation

PALEOGENE
- Metamorphosed basement

Fig 4.2.2

Horizontal Scale 1:50,000
0 500 1000 1500 2000 2500 3000 M.
0 250 500 750 1000 1250 1500 M.
Vertical Scale 1:25,000

PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE III

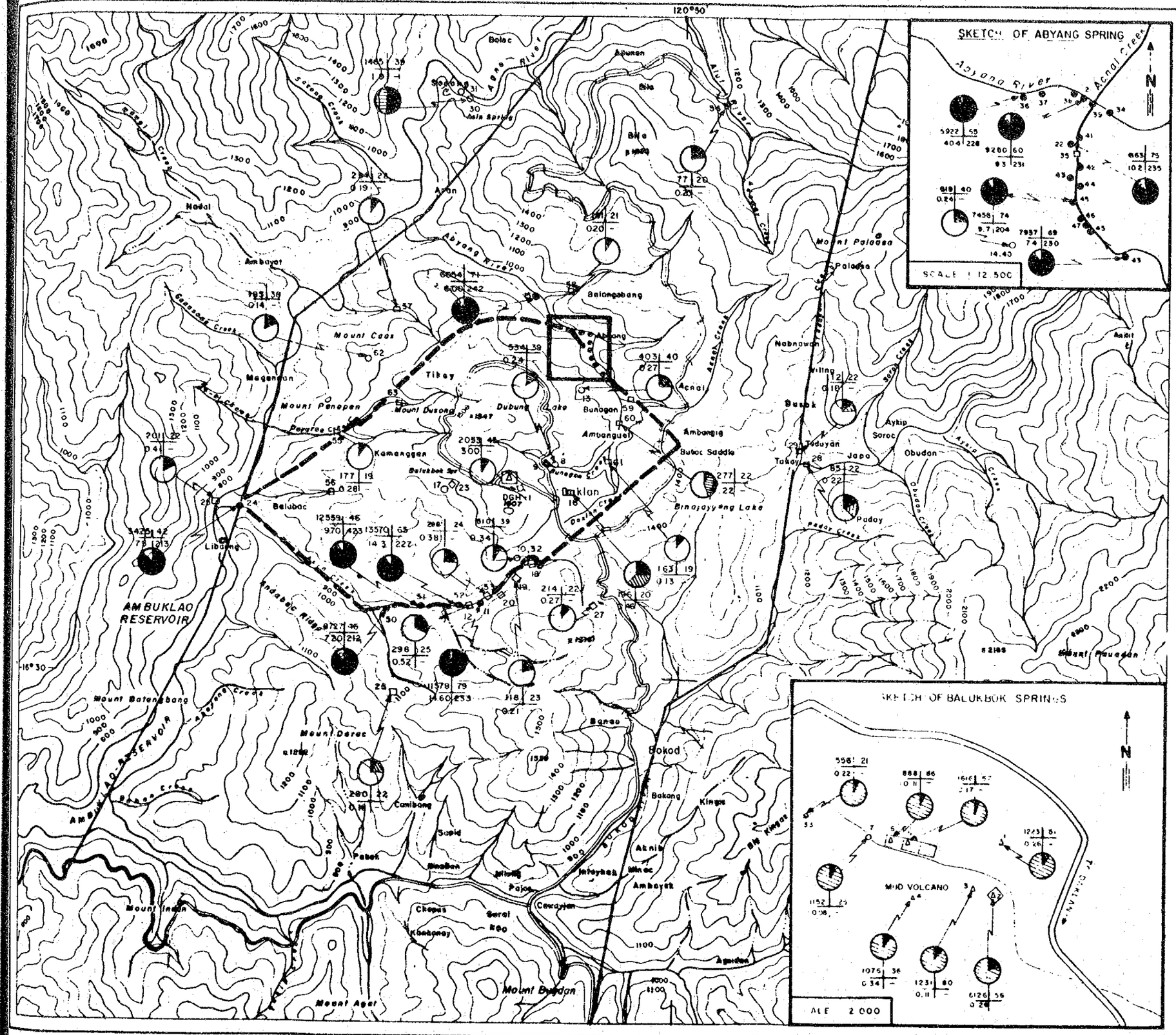
BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT

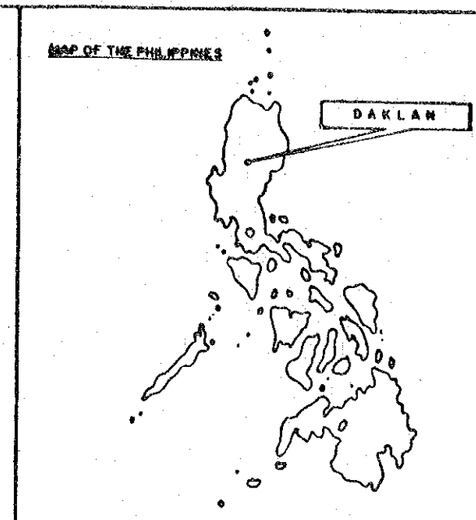
PRE-FEASIBILITY STUDY
DAKLAN - BOKOD (Benguet Province)
GEOLOGICAL SURVEY

GEOLOGICAL SECTIONS

PLATE 1103

DRAWN BY:	CHECKED BY:	APPROVED BY	DATE
			MARCH, 1980





INDEX MAP

- Boundary of graben
- Boundary of volcano-tectonic depression
- Δ Fumarole condensate
- Hot spring
- Warm spring
- Surface drainage/cold spring
- Gradient hole

HCO3% Cl% SO4%

TDS ppm | t°C
(Na+K)epm | Na-K-Ca °C
(Ca+Mg)epm

Fig 4.2.3

N

800 0 800 1000 1500 2000m

SCALE: 1:50,000

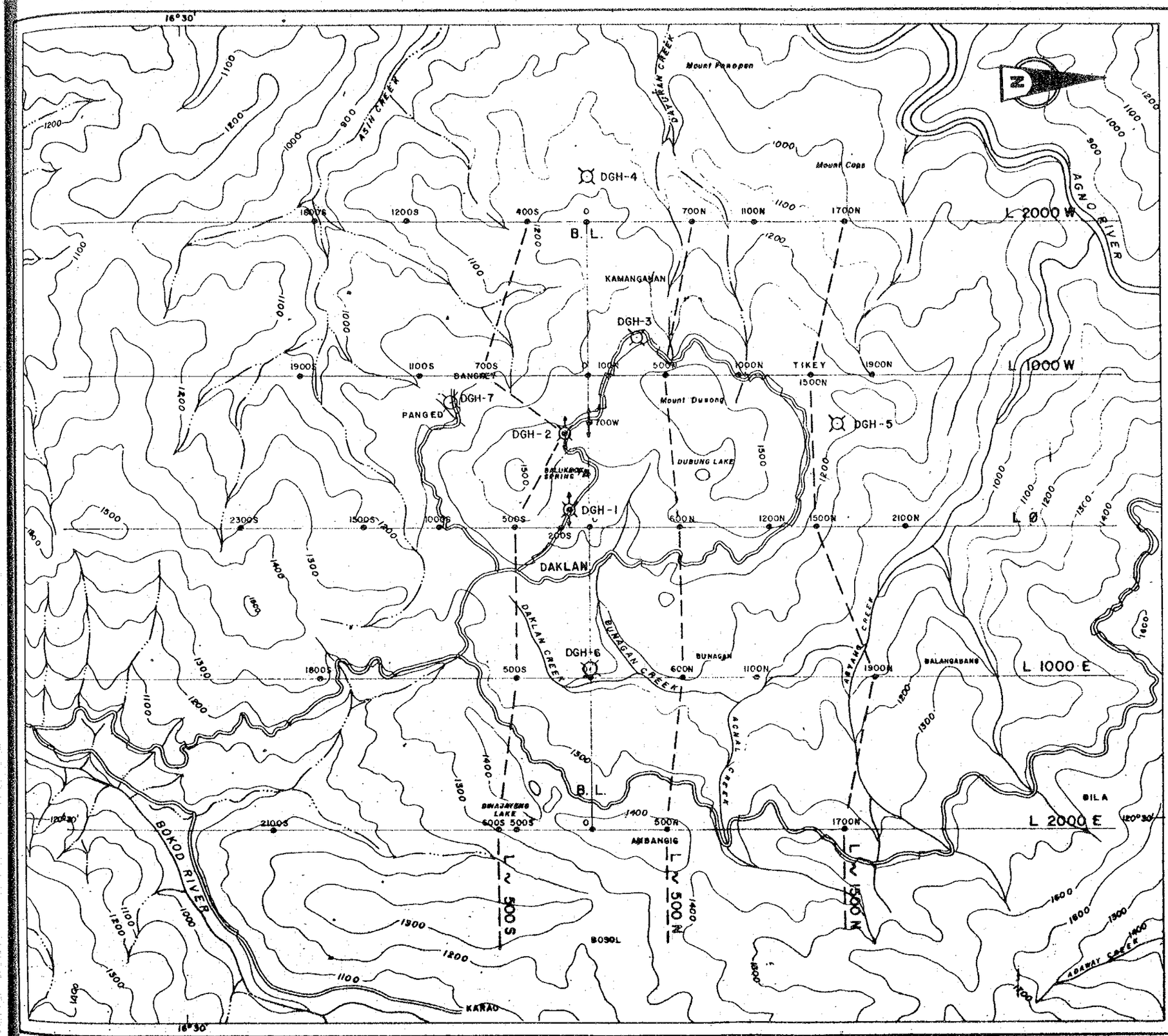
PHILIPPINE - ITALIAN TECHNICAL COOPERATION PROGRAM - STAGE III

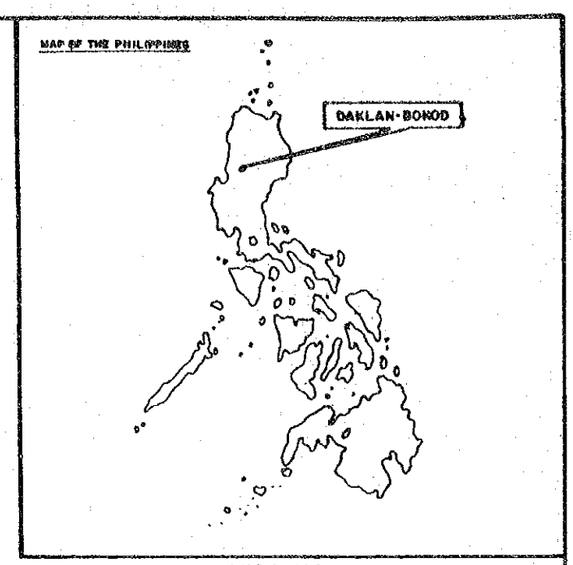
BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT

PRE-FEASIBILITY STUDY
DAKLAN - BOKOD (Benguet Province)
GEOCHEMICAL SURVEY
HYDROCHEMICAL MAP

PLATE
1201

DRAWN BY	CHECKED BY.	APPROVED BY





INDEX MAP

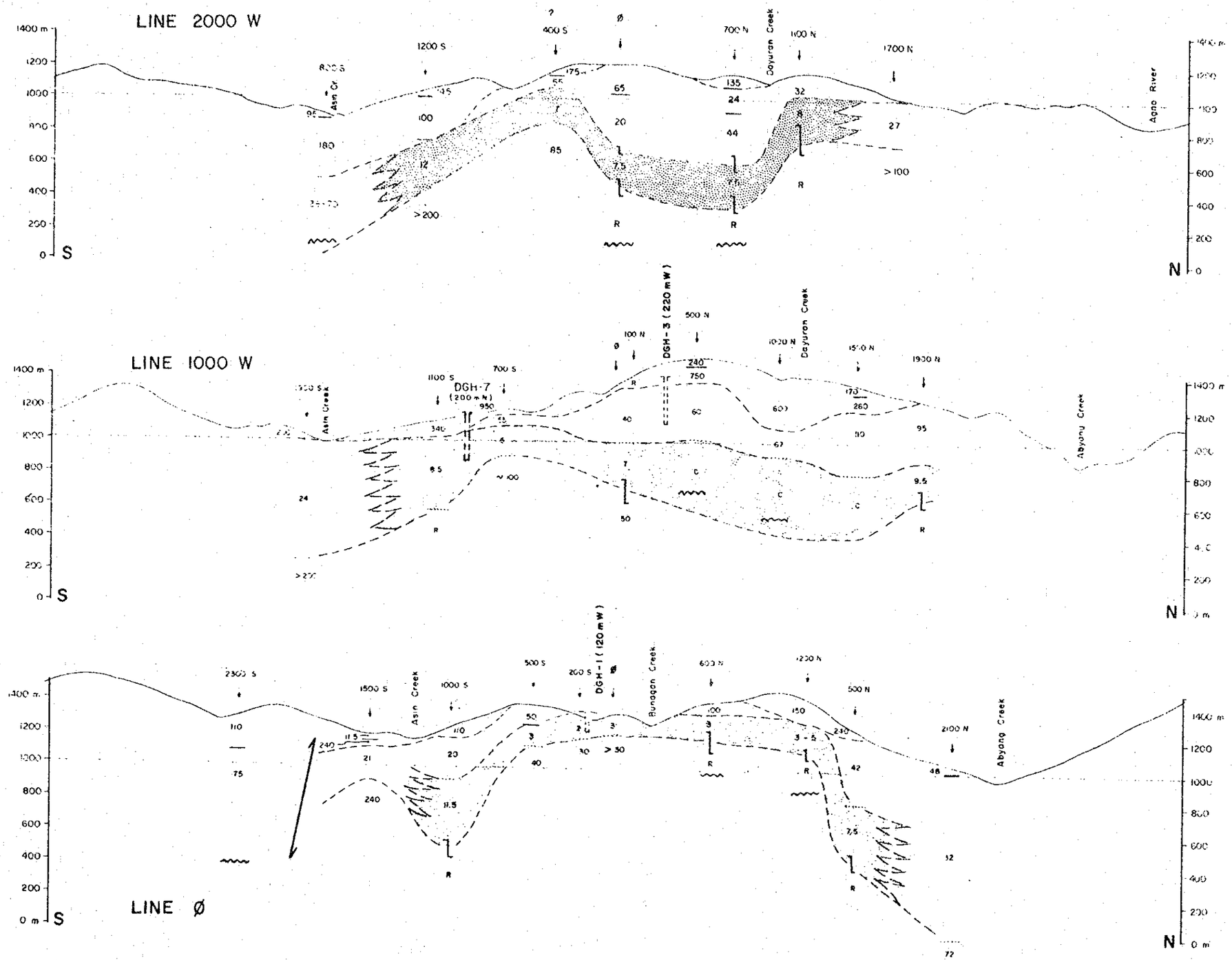
- Vertical electrical sounding (N - S azimuth)
- Vertical electrical sounding (W - E azimuth)
- Trace of cut line
- Trace of electrostratigraphic section (see Plates 1302 , 1 to 3)
- Gradient hole

Fig 4.2.4

0 250 500 750 1000 1250 1500 m

SCALE 1:25,000

PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE III			
BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT			
PRE-FEASIBILITY STUDY DAKLAN - BOKOD (Benguet Province) GEOELECTRICAL SURVEY LOCATION OF VERTICAL ELECTRICAL SOUNDINGS			PLATE 1301
DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE: MARCH, 1980



LEGEND :

- Vertical Electrical Sounding
- 60 Resistivity (ohm m)
- Resistivity Contact, well defined
- Resistivity Contact , approximat
- Resistivity Contact, with margin
- Contact of geoelectrical units
- Depth of penetration
- Geoelectrical lateral discontinui
- Conductive unit (S < 15 ohm
- Gradient hole, along the sect
- Gradient hole, offset

Fig 4.2.5.1

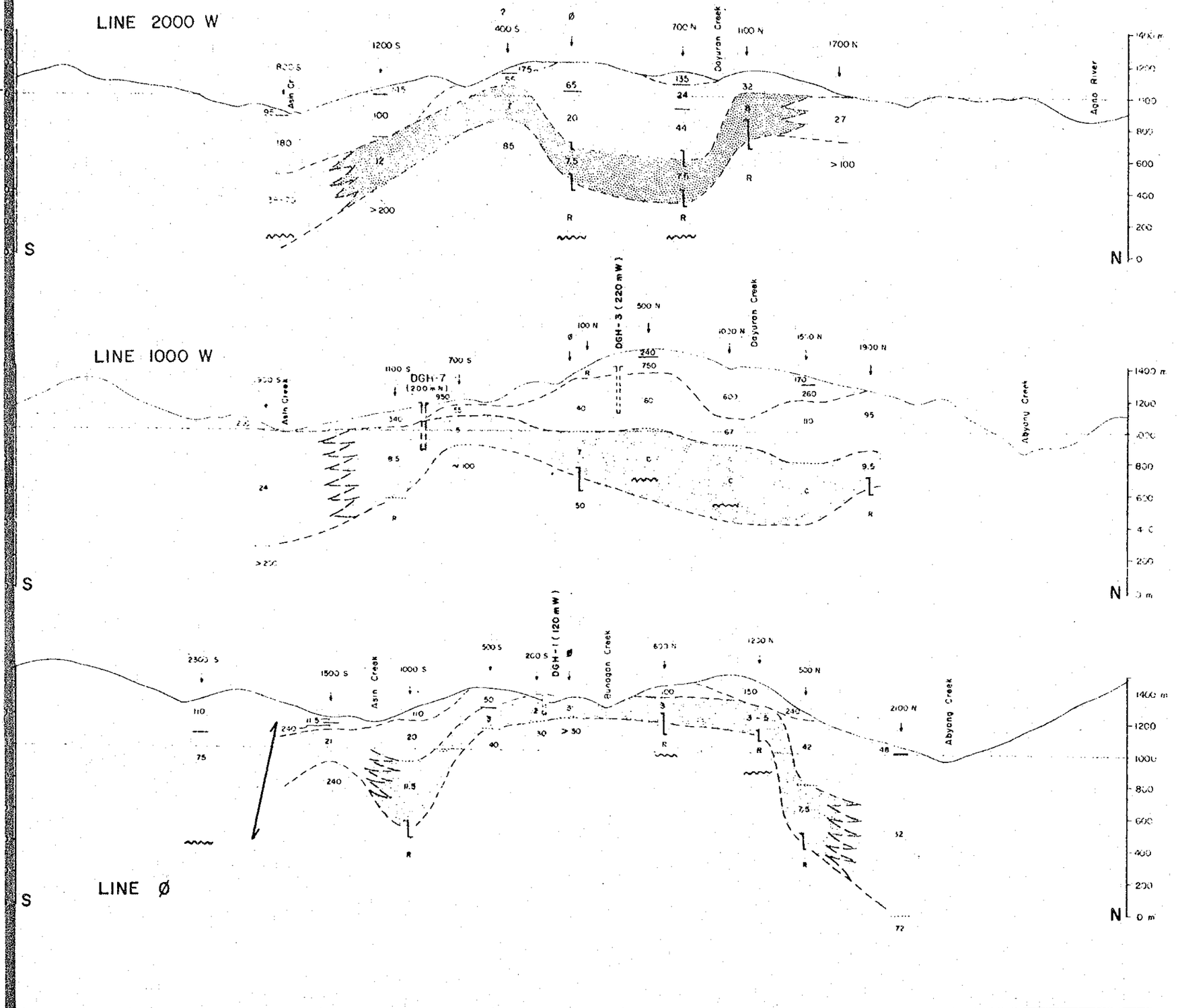
250 0 250 500 750
SCALE 1:25,000

PHILIPPINE - ITALIAN TECHNI
COOPERATION PROGRAM-STAGE

BUREAU OF ENERGY DEVELOPMENT - ELC ELE

PRE-FEASIBILITY STUDY
DAKLAN - BOKOD (Benguet Province)
GEOELECTRICAL SURVEY
ELECTROSTRATIGRAPHIC SECTIONS

DRAWN BY	CHECKED BY	APPROVED BY
E.R. dela CRUZ		



LEGEND :

- Vertical Electrical Sounding
- 60 — Resistivity (ohm m)
- Resistivity Contact, well defined
- Resistivity Contact, approximate
- Resistivity Contact, with margin of error
- Contact of geoelectrical units
- Depth of penetration
- Geoelectrical lateral discontinuity
- Conductive unit (ρ < 15 ohm.m)
- Gradient hole, along the section
- Gradient hole, offset

Fig 4.2.5.1

250 0 250 500 750 1000 m
SCALE 1:25,000

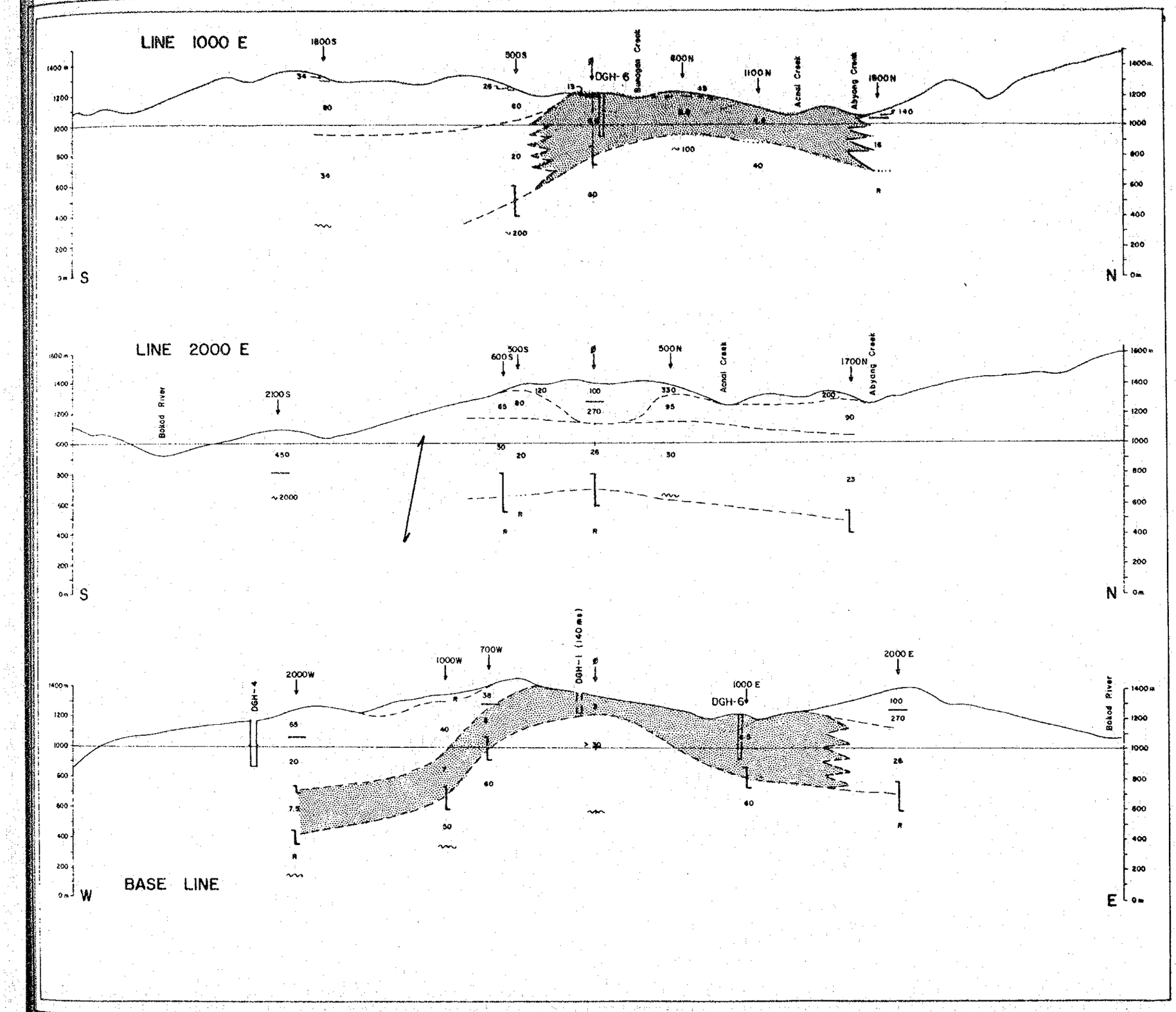
PHILIPPINE - ITALIAN TECHNICAL COOPERATION PROGRAM - STAGE III

BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT

PRE-FEASIBILITY STUDY
DAKLAN - BOKOD (Benguet Province)
GEOELECTRICAL SURVEY
ELECTROSTRATIGRAPHIC SECTIONS

PLATE 1302 1 of 3

DRAWN BY	CHECKED BY	APPROVED BY	DATE
E.R. dela CRUZ			MARCH, 1980



LEGEND :

- Vertical Electrical Sounding
- 80 — Resistivity (ohm.m)
- Resistivity Contact, well defined
- Resistivity Contact, approximate
- Resistivity Contact, with margin of error
- Contact of geoelectrical units
- Depth of penetration
- Geoelectrical lateral discontinuity
- Conductive unit (S < 15 ohm.m)
- Gradient hole, along the section
- Gradient hole, offset

Fig 4.2.5.2

250 0 250 500 750 1000 m.

SCALE 1:25,000

PHILIPPINE - ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE III

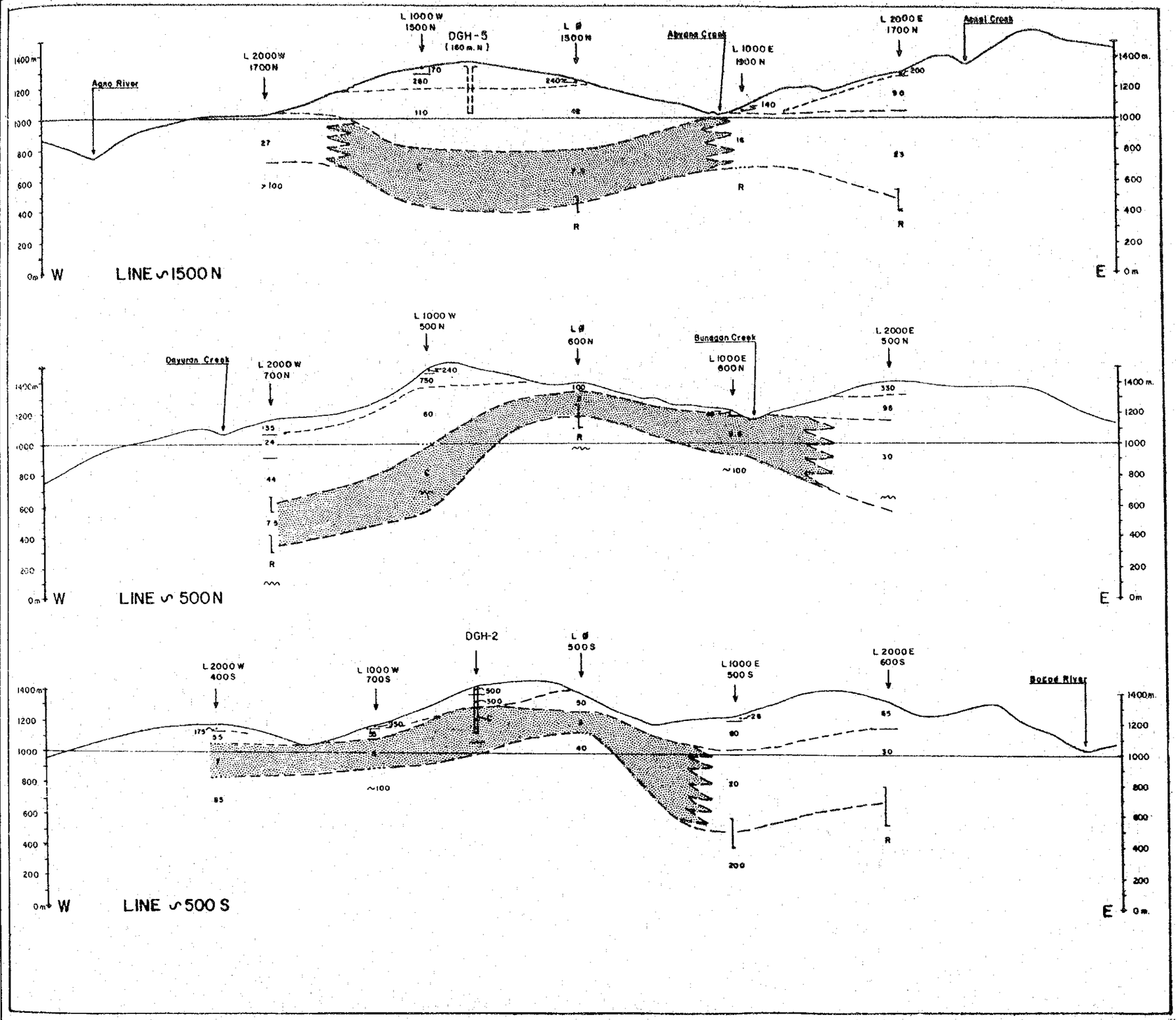
BUREAU OF ENERGY DEVELOPMENT-ELC ELECTROCONSULT

PRE-FEASIBILITY STUDY
DAKLAN - BOKOD (Benguet Province)
GEOELECTRICAL SURVEY

ELECTROSTRATIGRAPHIC SECTIONS

PLATE 1302 2 of 3

DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
			MARCH, 1980



LEGEND :

- Vertical Electrical Sounding
- 60 Resistivity (ohm.m)
- Resistivity Contact, well defined
- Resistivity Contact, approximate
- Resistivity Contact, with margin of error
- Contact of geoelectrical units
- Depth of penetration
- Geoelectrical lateral discontinuity
- Conductive unit (9 < 15 ohm.m)
- Gradient hole, along the section
- Gradient hole, offset

Fig 4.2.5.3

0 250 500 750 1000 1250 1500 M.
SCALE 1:25,000

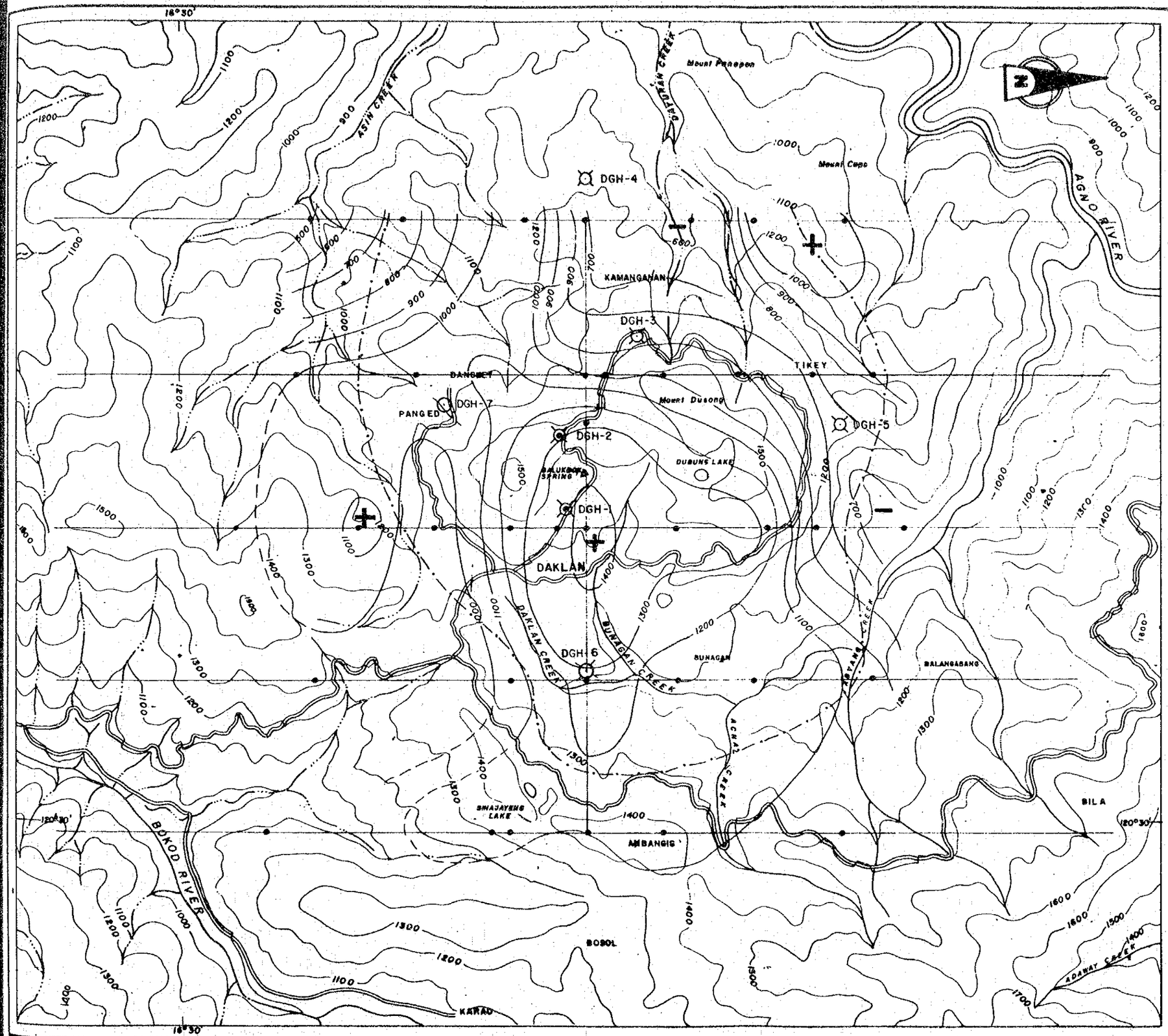
PHILIPPINE–ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE III

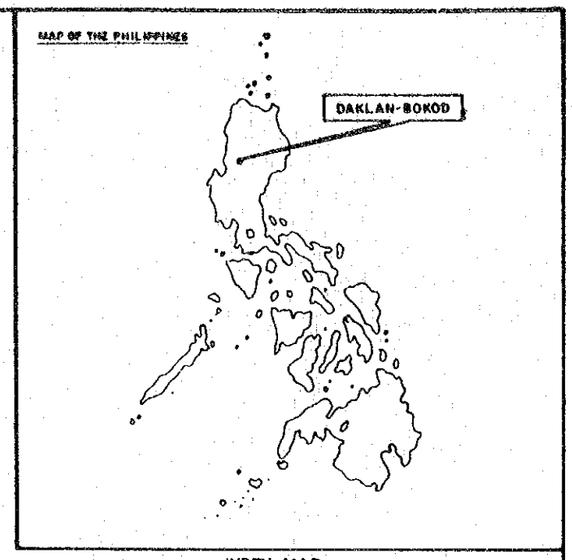
BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT

PRE-FEASIBILITY STUDY
DAKLAN – BOKOD (Benguet Province)
GEOELECTRICAL SURVEY
ELECTROSTRATIGRAPHIC SECTIONS

PLATE
1302
3 of 3

DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
			MARCH, 1980





INDEX MAP

- Vertical electrical sounding
- Contour lines (elevation in m a.s.l.)
- Boundary of conductive unit ($\rho \leq 15$ ohm. m)
- Gradient hole

Fig 4.2.6

0 250 500 750 1000 1250 1500 M.

SCALE 1:25,000

PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE III

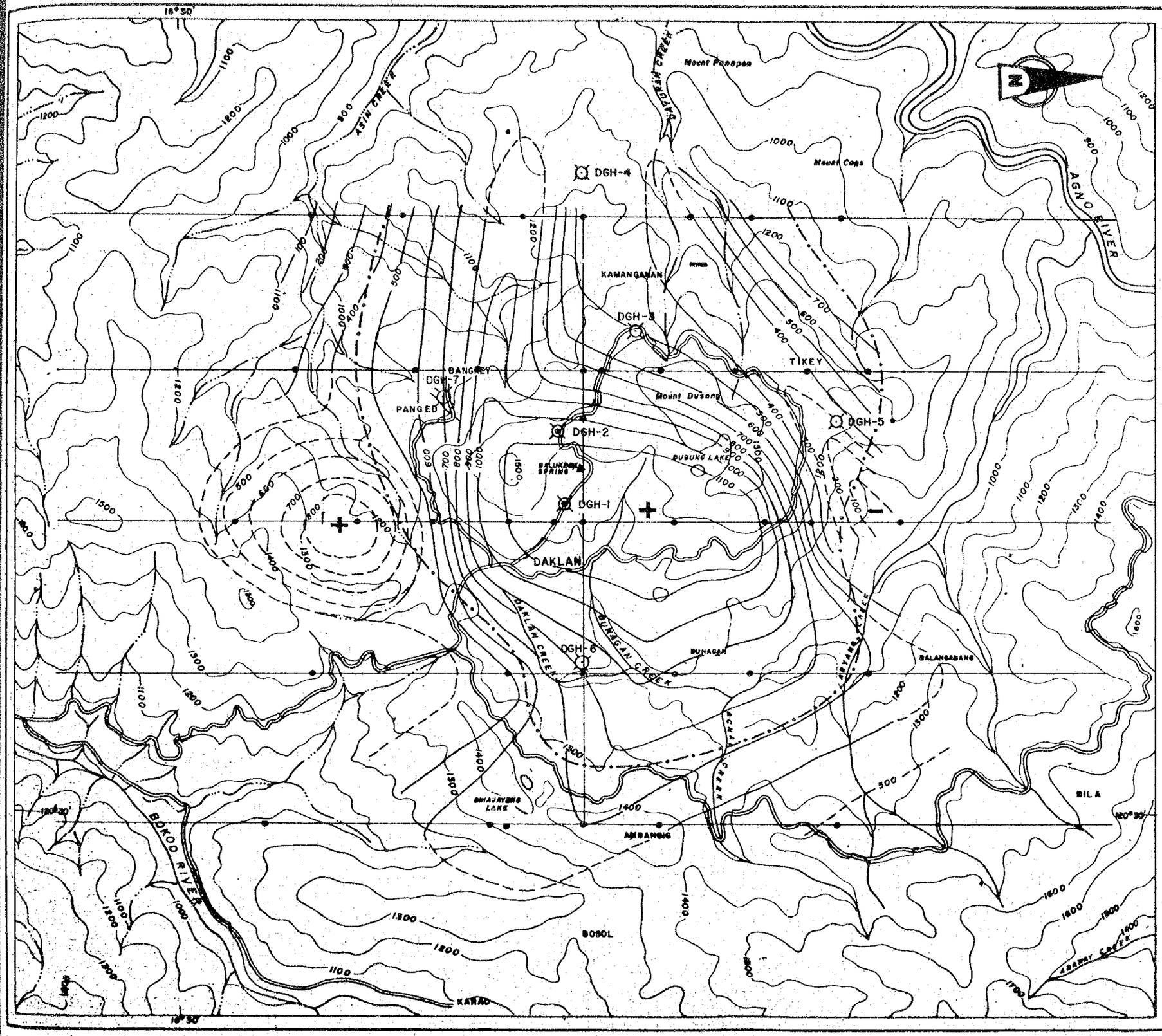
BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT

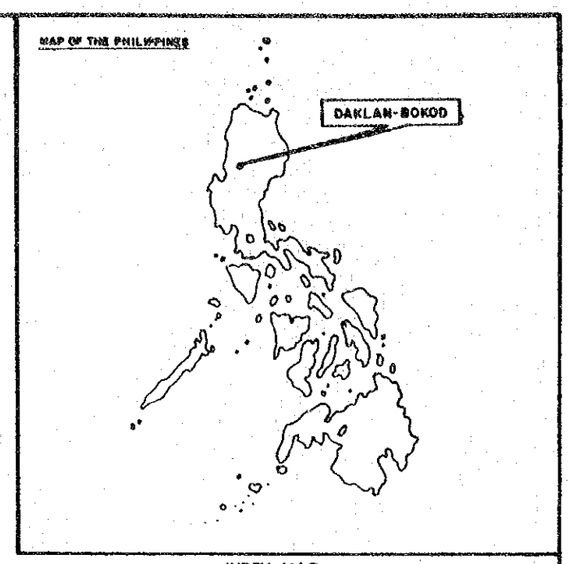
PRE-FEASIBILITY STUDY
DAKLAN-BOKOD (Benguet Province)
GEOELECTRICAL SURVEY

CONTOUR LINES OF THE TOP OF THE CONDUCTIVE UNIT

PLATE 1303

DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
			MARCH, 1980





INDEX MAP

- Vertical electrical sounding
- Contour lines (elevation in m a.s.l.)
- Boundary of conductive unit ($\varrho <$ 15 ohm.m)
- Gradient hole

Fig 4.2.7

0 250 500 750 1000 1250 1500 M.

SCALE 1:25,000

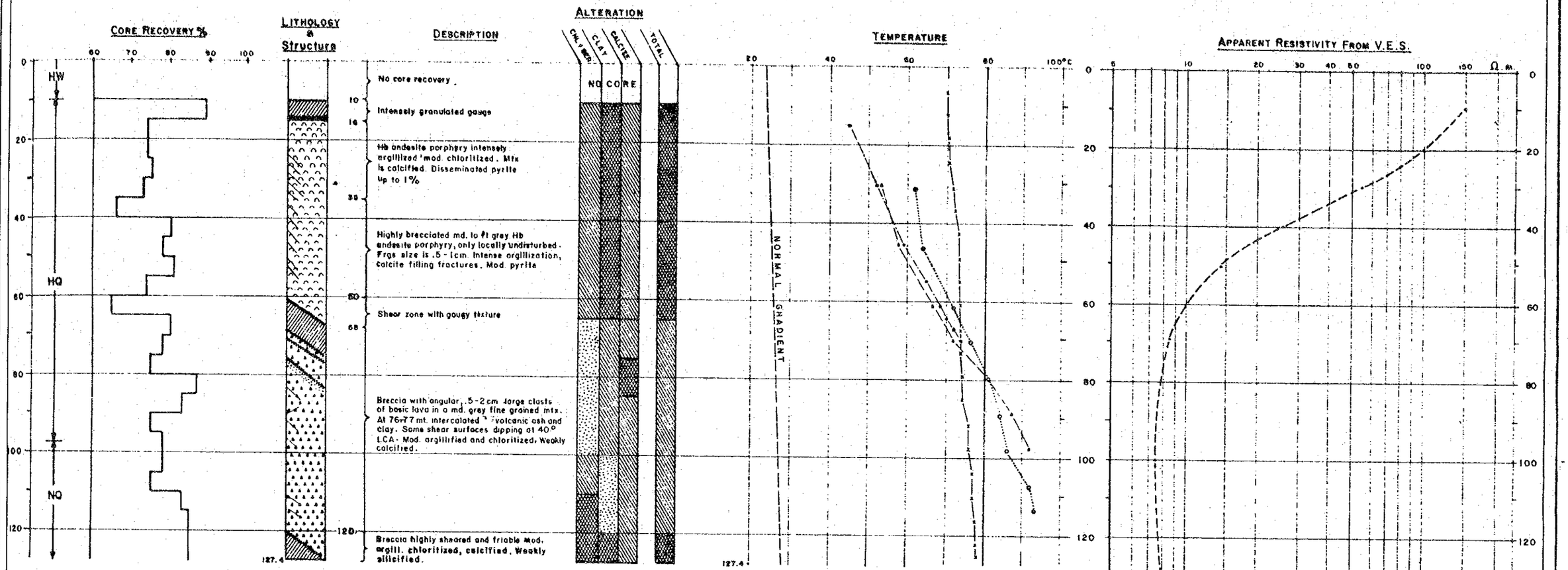
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE III

BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT

PRE-FEASIBILITY STUDY
DAKLAN – BOKOD (Benguet Province)
GEOELECTRICAL SURVEY
CONTOUR LINES OF THE TOP OF THE RESISTIVE BASEMENT

PLATE 1304

DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
			MARCH, 1980



LEGEND

LITHOLOGY & STRUCTURE

- Hb andesite porphyry
- Breccia
- Volcanic ash and clay
- Fault zone
- Shear zone
- Fracture

ALTERATION

MINERALS	TOTAL
Fresh	< 2% — < 5%
Low	> 2 < 10% — > 5 < 20%
Moderate	> 10 < 20% — > 20 < 40%
Intense	> 20% — > 40%

TEMPERATURE

- 7-18-79 24 hrs. standby
- 7-20-79 34 hrs. standby
- 7-23-79 29 hrs. standby
- 7-30-79 6 days after discharge

Spudded : July 13, 1979

Completed : July 24, 1979

Total depth : 127.4 m.

Water table : 11m. b.g.l.

Coordinates: 16° 31' 21" N, 120° 48' 52" E, 1335 m. a.s.l.

Fig. 4.2.8

0 10 20 30 40 50 m
SCALE 1 : 1,000

PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE III

BUREAU OF ENERGY DEVELOPMENT — ELC ELECTROCONSULT

DGH 1 | PLATE

DRAWN BY: | CHECKED BY: | APPROVED BY: